Section 3 – Technical Standards & Best Practices
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Section 3 – Technical Standards & Best Practices

I. Health and Safety

Health and safety issues have become an important part of the Weatherization Assistance Program (WAP) as knowledge about the hazards within dwellings has increased since the Program's inception. When a health or safety hazard is detected, it is the policy of the Department of Natural Resources' Energy Center (DNR/EC), administrator of the Missouri Weatherization Assistance Program, to address the hazard. This policy is tempered by recognition that the primary goal of the WAP is energy conservation and that funds should focus on that goal. Although balance is needed between these competing issues, the health and safety of the building, occupants and weatherization crews or contractors shall not be compromised by any retrofit material, technique or practice.

The following sections establish areas of concern that may affect the health and safety of the workers and the clients. In most cases, the best approach to limiting the health and safety risk is to minimize their exposure to the hazard. The inability to minimize exposure may result in some or all of the work being stopped on any particular dwelling.

A. Crew/Contractor Safety

A subgrantee is responsible for complying with Occupational Safety and Health Administration (OSHA) requirements in all weatherization activities that involve staff personnel. When contractors are employed by subgrantees, those contractors also are required to comply with OSHA. For detailed information on worker health and safety, refer to *Construction Industry OSHA Safety and Health Standards* (29 CFR 1926).

The DNR/EC expectation is for crews, contractors and auditors to be able to work under conditions that do not jeopardize their own health and safety. The office, warehouse and other workspace owned or rented by each subgrantee should be a safe and healthy environment.

The contractor cost to comply with OSHA, as applicable, is part of the contracted bid price. related costs for subgrantees to comply with OSHA requirements may be charged as tools and equipment. Subgrantees are responsible for purchasing all OSHA required tools and equipment and are required to immediately repair or replace any defective tool or equipment. **Work that threatens worker or client health or safety may not be undertaken**.

1. General Guidelines.

The following are general guidelines for accident prevention and should be followed by agencies, crews, auditors and general contractors involved in weatherization work. In addition, this section outlines some of the employer responsibilities to the weatherization crews.

a) The subgrantee or contractor has the responsibility, as employers to initiate and maintain such programs as may be necessary to comply with this part.

b) The employer shall provide training in the area of health and safety that will allow weatherization personnel to identify existing and potential threats to the client's or crew's health and/or safety. Upon the identification of a threat to the client's health and/or safety, the client will be informed in writing as to the available options for dealing with this threat.

c) The employer shall provide for frequent and regular inspections of the job sites, materials and equipment to be made by competent persons designated by the employers.

d) The employer shall tag all machines, tools, materials or equipment identified as being unsafe, make them inoperable by locking the controls or physically remove them.

e) The employer shall permit only those employees qualified by training or experience to operate equipment and machinery.

f) The employer shall require its employees and its representatives to take all reasonable precautions against performing work on homes that will subject clients to health and safety risks. At the time of initial client contact, the weatherization worker will make a cursory evaluation of the individual health of the homes occupants. In cases where a person's health is fragile and/or the crew work activities constitute a health or safety hazard, those occupants at risk will be asked to leave during the work activities.

g) The DNR/EC will allow technical waivers for non-performance of audits, installations and/or inspections, or any portion of these functions, if such action will expose workers to conditions regarded as unsafe or unhealthy as determined by OSHA Construction Industry Standards.

h) Expenditure of weatherization funds for materials, protective clothing, respirators, medical exams, proper tools and equipment and other items or activities related to the health and safety of clients and workers are allowable health and safety costs under the Missouri Weatherization Assistance Program.

i) When in doubt, subgrantees should seek consultation services from an OSHA subsidized professional safety consultant (See: OSHA Publication #3047, Consultation Service for the Employer) for identifying hazards and developing a worker health and safety program.

2. Subgrantee Health and Safety Policy

A subgrantee must have a Health and Safety Policy in place to protect worker health and safety. This policy should contain the following:

a) Material Safety and Data Sheets (MSDS) on the job site and available to medical personnel.

b) Employees should know where to go for treatment.

c) A written procedure for reporting medical emergencies.

d) A written procedure for reporting non-emergency accidents.

e) Provision for prompt medical attention for serious injuries.

f) Prompt transportation or a system for contacting an ambulance, in the case of a serious emergency.

g) Telephone numbers of physicians, hospitals or ambulances should be conspicuously posted.

3. Subgrantee First Aid Program

A first aid program should be in place. At minimum, the program should include the following:

a) First aid training provided to at least one member of each crew.

b) CPR training provided to at least one member of each crew.

c) One complete first aid kit per vehicle.

d) One eyewash station with at least one refill per vehicle.

4. Subgrantee Personal Protection Program

Subgrantees must establish a Personal Protective Equipment Program. This program should include the following:

a) Respiratory Protection Procedures that provide employees with the following:

(1) The proper personal respiratory protection equipment.

(2) Respirator fit testing, by a trained person.

(3) Training to employees on respirator use.

(4) Medical examination of pulmonary capacity with a frequency recommended by appropriate OSHA standards.

b) Eye protection should e made available when appropriate.

c) Gloves and protective coveralls should be made available when needed to protect worker health or safety.

5. Subgrantee Tool Safety Program

Agencies should have in place a Tool Safety Program designed to protect employees from work place hazards. This program should ensure the following:

a) Tools are safe and adequate for the job.

b) Ground-fault protection is provided for power tools.

c) Employees are trained in the safe and proper operation of tools and equipment used in their work.

d) Safety guards are in place on all tools that come equipped with such devices.

e) Ladders and scaffolding are adequate for use, have the proper weight rating, and are constructed of non-conductive material.

f) That hearing/ear protection is provided to individuals working around high decibel equipment or in high dust environments.

6. Subgrantee Fire Protection Program

Agencies are encouraged to implement a Fire Protection Program. This program should include the following:

a) Fire extinguishers are provided and are located in the subgrantee offices and warehouse, located in each vehicle and that each is inspected regularly.

b) Training on fire extinguisher use.

c) Fire emergency procedures.

7. Subgrantee Job Hazards Identification Program

Agencies are encouraged to implement a Job Hazards Identification Program. This program should include the following:

a) Investigation for job specific safety hazards.

b) Hazard Communication Procedures that include the following:

(1) Written policies for dealing with job hazards.

(2) All hazardous materials containers labeled with:

(a) Hazardous chemical contents.

(b) Hazard warning appropriate for employee protection.

(c) Legible and prominent labels on all containers.

c) Means of communication for non-routine tasks and unlabeled chemicals.

d) A means for the exchange of information between subgrantees and contractors regarding hazardous materials.

8. Material Safety Data Sheet Catalog

Agencies should develop and maintain a catalog of Material Safety Data Sheets (MSDS) for all hazardous material and should be made available to all employees, kept on file at the subgrantee offices and on all job sites. The MSDS catalog should contain the following:

a) Specific identity of chemical and common name.

b) Physical and chemical characteristics.

c) Known acute and chronic health effects and related health effects.

d) Precautionary measures.

e) Exposure limits.

f) Identification of carcinogens.

g) First aid procedures.

B. Building/Occupant Safety

To ensure appropriate consideration for health and safety, relevant procedures and assessments will be conducted as part of the building analyses. Each home weatherized must be individually assessed to determine the existence of potential hazards to workers or clients. When conditions within the home are such that the health and safety of the client, crew or contractor will be jeopardized prior to providing assistance, weatherization must not proceed until such problems are remedied. In some cases mitigation of problems may be beyond the scope of the WAP. In these instances, the agency must invoke the "Walk Away"

Policy and the client must be notified in writing and referred to any alternative resources that are available for solution of the problem.

In those instances where the existing conditions pose a threat to the crew or contractor's health and safety, the Missouri Weatherization Assistance Program allows *technical waivers* for any audit or inspection process installation or any portion of the weatherization activity. Efficient auditing protocol would make a walk-away determination as early in the inspection process as possible, yet thorough to the point of documenting necessary actions to be taken by the client for weatherization to proceed.

Under the DNR/EC Health and Safety Standards, the following subsections describe the health and safety assessments and associated actions that must be performed:

1. **Carbon Monoxide**

   a) When combustion appliances are present in the dwelling, or where there is reason to suspect a significant level of carbon monoxide (CO) present in the ambient air (such as with an attached garage) the ambient air will be tested for CO at the initial building audit and immediately after the implementation of weatherization measures. The testing procedure is:

      (1) Establish building in the winter (heating season) mode with exterior windows and doors closed.

      (2) Calibrate CO testing equipment in the outdoor ambient.

      (3) Enter building and walk-through the various rooms and locations and note any areas where CO above outdoor ambient is found.

      (4) If levels higher than 9 parts per million (ppm) above outdoor levels are found, turn off all combustion appliances and ventilate the unit(s).

      (5) If measurable levels are 35 ppm or higher than outdoors, remove the occupants, turn off combustion appliances, ventilate the building and contact fuel vendor before continuing test.

      (6) If ambient CO levels are lower than 9 ppm above outdoors, proceed with testing of combustion appliances.

   b) CO alarms should be installed in all homes where a furnace return air could back draft a space heater, wood stove, fireplace or water heater. Refer to the Missouri Weatherization Field Guide for additional detail on installation and consult manufacturer's recommendations.

   c) Smoke alarms should be in every home and should be installed if not present in a home receiving weatherization services. A smoke alarm should be installed near

combustion zone(s) and one near bedrooms. Refer to the Missouri Weatherization Field Guide for additional detail on installation and consult manufacturers' recommendations.

2. Combustion Systems

a) DNR/EC considers an operable, unvented space heater in a dwelling a potential health and safety hazard. U.S. DOE now distinguishes between primary and secondary unvented space heaters as heat sources (See *Attachment 3-1*).

b) All conventionally vented (this excludes direct-vent appliances) combustion appliances must be tested for proper draft using the worst-case draft procedures in Section III.

(1) Worst-case draft testing **must** always be done after all weatherization measures are installed.

(2) Worst-case draft testing is suggested before weatherization work begins in dwelling where:

(a) There is ductwork installed in a Combustion Appliance Zone (CAZ); or

(b) The auditor/estimator has reason to believe that worst-case draft testing would reveal useful information.

c) Subgrantees must seek to eliminate conditions where carbon monoxide levels are at or over the levels stated in Table III-3.

d) Carbon monoxide testing of space and water heating appliances must be done with a digital carbon monoxide meter before dilution air enters the vent system. If there is a flue opening for each burner, the best must be done in each flue opening individually.

e) When there is an atmospheric combustion appliance in a bedroom,

(1) The appliance must be isolated from the bedroom air by drawing combustion air from another appropriate source;

(2) If the appliance is replaced, a sealed combustion system must be installed; or

(3) The appliance should be moved to a more appropriate location.

f) A heat shield must be installed when it is determined that a venting system is too close to combustible materials or the venting system must be moved to ensure proper clearance.

g) All visible fuel lines must be tested for fuel leaks both outdoors and indoors, starting at the meter or LP tank.

h) Remove all non-functioning humidifiers from forced air furnace systems with prior client approval.

i) All gas valves should have at least a single safety. If a gas valve has no safety, then the subgrantee should replace the gas valve with the most cost-effective replacement:

   (1) A 100% safety millivolt gas valve.

   (2) A 100% safety 24 volt gas valve.

   (3) A remote bulb gas valve.

j) When there is a suspicion that the pilot safety system is not functioning properly, subgrantees should perform a simple test of the pilot safety device to ensure that it is functioning properly. Procedures for this test are:

   (1) Light pilot and let it warm the thermocouple for at least one minute. Do not operate the heater during this time.

   (2) Observe the second hand on a watch or clock, then either blow out the pilot flame or put controller to the off position.

   (3) Count the number of seconds from when the pilot is shut off until you hear the sound of the electromagnet valve closing shut.

   (4) A good drop out time is usually 20 to 30 seconds; longer is better. Heaters equipped with power vents have drop out times of 10 to 15 seconds.

   (5) Repeat the test to confirm it is consistent.

k) Subgrantees should use a non-contact voltage sensor to ensure that the main switch will properly turn off the electricity to a space heating unit.

l) All 110 volt wiring connections should be secured with wire nuts and electrical tape, and enclosed in an electrical junction box or other appropriate enclosure.

m) The proper size and type of wire should be used. The wire should have the correct rating for voltage, amperage, and heat exposure.

n) Draft hoods, draft diverters, and barometric dampers should be well secured to the appliance, level, and should not reduce or restrict the size of the vent.

o) All gas ranges should be tested for carbon monoxide according to Subsection III – Mechanical Systems and Combustion Appliances.

p) Flexible gas connectors installed by subgrantees should be installed so that they do not pass through the appliance body.

q) All direct vent (sealed combustion) water heating and space heating appliances with visual indicators of a potential carbon monoxide problem, such as carbon build-up, must be tested for carbon monoxide.

3. Response to Combustion Appliance Problems

a) The subgrantee should determine if it is best to contact the local gas company or oil dealer to correct these problems. Gas utilities always have their own emergency response protocols and these should be respected. The items listed below are not intended to interfere with gas utilities emergency protocols (often called tagging procedures).

b) In each of the situations in Subsection 3, the auditor or appliance technician will evaluate the client's situation, in consultation with the Subgrantee Weatherization Director, for the purpose of determining if:

(1) The client can safely remain in the home if an alternative source of heat (portable electric space heaters) can be obtained or whether the client must be relocated for a short time.

(2) If the technician believes the client cannot safely remain in the home, they will be advised to make arrangements to stay with family or friends until the unit can be occupied again.

(3) Documentation supporting the needed repairs must be kept in the client file. Repairs done under the Weatherization Program must be included as part of the SIR calculation computed by the NEAT computerized audit unless done to protect the client's health and/or safety. Clients without heat during the heating season shall be provided with temporary heating appliances to ensure thermal comfort, stabilize the situation and prevent damage to the dwelling.

4. Emergency Situations, Immediate Follow-up Required

Some safety problems may warrant a discontinuing of the combustion appliance testing or shutting off the appliance until the repairs can be made. When this situation occurs for a space heating appliance, the client must be left with an alternative source of heat. Whenever a technician questions the safety of a situation, they should consult a supervisor.

Examples of this type of situation are:

a) ***Major Natural Gas Leak*:** Gas can be smelled more than two feet from the gas line.

b) ***Major Propane Gas Leak*:** Propane can be smelled more than three feet from the leaking fitting.

c) ***Clogged or Disconnected Flue*:** A clogged or disconnected flue that cannot be fixed, causing significant spillage of combustion products into a heated space, or working area of the technician.

d) ***Back drafting or Significant Spillage*:** Any back drafting of combustion products in combination with carbon monoxide indications, which cannot be fixed.

e) ***Cracked Furnace Heat Exchanger*:** Any visually identified cracked heat exchanger leaking combustion products in combination with positive carbon monoxide or others.

f) ***Other Hazards*:** Any other situation or combination of situations which the technician or supervisor judges hazardous to the health of the client or others.

5. Non-Emergency, One-day Follow-up Required

Some situations may not warrant discontinuing testing or shutting down the heating system, but are serious enough to require attention within twenty-four hours. Examples of this type of situation are:

a) ***Cracked Heat Exchanger*:** Visually identified cracked heat exchanger that is leaking combustion products, with no carbon monoxide indications.

b) ***Spillage*:** Spillage but no carbon monoxide indications in a heated space.

c) ***Propane or Natural Gas Leak*:** Propane can be smelled, but not more than three feet from the leaking fitting.

d) ***Carbon Monoxide*:** Measured carbon monoxide levels must comply with Table III-3 in Subsection III, and there must be an adequate draft and no spillage.

e) ***No Limit Switch*:** A furnace with no limit switch that poses a safety issue or a limit switch that is disconnected.

6. Non-Emergency, Five-day Follow-up Required

All other safety related follow-up must begin within five days unless the system or service can be shut-off until repairs are made. Examples of this type of situation are:

a) ***Draft*:** Unacceptable draft with spillage in an unheated area.

b) ***Propane or Natural Gas Leak*:** Gas can be smelled, but not more than two feet from the gas line.

c) ***Limit*:** A furnace limit switch that does not shut the gas off by 225° F.

d) ***Suspicion of a Cracked Furnace Heat Exchanger*:** A cracked heat exchanger is suspected, but there are not other apparent problems with the furnace.

7. Blower Door Safety

a) If a dwelling is tightened to a CFM_{50} level less than the calculated Building Airflow Standard for that Dwelling, actions to remedy the situation should be taken and may include properly sized, continuously operating mechanical ventilation. Refer to the calculated Building Airflow Standard CFM_{50} value for the home.

b) Do not conduct a depressurization blower door test while a wood stove, fireplace or a vented space heater is operating. If one of these appliances is operating, it **will not** be considered sufficient reason for never conducting a blower door test. Weatherization personnel are expected to shut down the appliance to conduct the test or revisit the dwelling at a time when the appliance is not operating.

c) Do not conduct a depressurization blower door test when any combustion appliance is operating. Standard practice is to positively shut off conventionally vented combustion appliances before the blower door test is conducted. A procedure should be in place to ensure that the appliance is returned to the pretest condition. Exceptions to appliance shut down include:

(1) Direct-vent (sealed combustion) appliances.

(2) Unvented gas appliances, such as most gas ranges.

8. Moisture

All homes should be checked for previous or existing moisture problems. Repair of moisture problems that might: 1) result in health problems for the client, 2) damage the structure over the short- or long-term, or 3) diminish the effectiveness of the weatherization measures, must be done before the weatherization job is completed. The moisture assessment section of the Auditor Field Form must be filled out along with special attention to the following:

a) Evidence of condensation on windows and walls indicated by stains or mold.

b) Standing water, open sumps, open wells, dirt floors, water stains, etc. in basements. Also, check to see if firewood is stored in the basement and whether laundry is hung to dry during the winter months.

c) Leaking supply or waste pipes.

d) Attic roof sheathing shows signs of mold or mildew.

e) Identification of existing or potential moisture problems shall be documented in the client file.

f) If existing moisture problems are found, no air sealing should be done unless the source of the moisture can be substantially reduced or effective mechanical ventilation can be added to cost-effectively remove the moisture. In some cases, air sealing must be done in order to reduce the source of the moisture (i.e. sealing off crawlspaces from the house, or sealing attic leakage to eliminate condensation on the roof deck).

g) Because air tightening may cause an increase in relative humidity, client education should include information about moisture problems and possible solutions.

h) In the course of weatherization, any low-cost measures that help reduce the humidity levels in the house should be installed. Examples of these activities are venting dryers, venting existing bath or kitchen exhaust fans or installing moisture barriers on dirt floors.

i) A dwelling that has a CFM_{50} greater than the Building Airflow Standard (BAS) is no guarantee that moisture will not be a problem in that home.

9. Hazardous Conditions & Materials

a) Subgrantees should minimize or restrict the use of materials that may be hazardous to the client, however if the subgrantee must utilize hazardous materials, including chemicals, such use must be discussed with the client prior to using.

b) If strong smelling chemicals, such as formaldehyde, are detected in the client's home, subgrantees should not perform any weatherization measures that would reduce the natural air leakage of the dwelling.

c) The installation of hazardous materials that must be used for effective weatherization must be done used in well-ventilated areas.

d) Asbestos Inspection Procedures.

(1) Prior to performing work or conducting tests, the energy auditor must conduct an inspection for materials suspected of containing asbestos if there is the possibility that they may be disturbed during the weatherization testing or work.

(2) Decisions on approaches to weatherization work where asbestos is present shall be based on the judgment of the most qualified individual available to the subgrantee.

(3) When major energy saving measures might be sacrificed as a result of suspected asbestos-containing materials, the subgrantee may have the suspected material tested for asbestos content.

(4) All subgrantee workers must wear high quality respirators any time asbestos is worked with.

(5) When materials containing asbestos are worked with, the asbestos materials should be dampened with water whenever possible to reduce the risk of airborne asbestos fibers.

(6) Materials containing asbestos may not be cut, drilled, or disturbed in any manner that may cause asbestos fibers to become airborne.

(7) Subgrantees may not use abatement contractors to remove or dispose of asbestos containing materials without prior authorization from the Missouri Weatherization Program Administrator.

10. Electrical Safety

a) Knob-and-Tube Wiring.

(1) If knob-and tube wiring is active in an attic, any insulation must be keep at least three inches from the wiring. Blown insulation must be appropriately dammed to keep the insulation from advancing closer than three inches from the knob-and-tube wiring.

(2) If active knob-and-tube wiring is found in a dwelling attic, walls, or basement, the walls of the dwelling must not be insulated.

(3) If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, the attic and walls may be insulated without special precaution.

b) Ground-Fault Interrupt Circuits.

(1) Ground-fault circuit interrupter (GFCI) devices should be tested to ensure that they are working properly in dwelling bathrooms and kitchens.

(2) If a GFCI is not installed in a dwelling bathroom, a subgrantee may have one installed if appropriate.

11. Lead-safe Weatherization

Lead-based paint dust and other residues are hazards that Weatherization workers are likely to encounter in older homes. HUD estimates that four million homes have significant lead-based paint hazards. Furthermore, Weatherization work may directly disturb lead-based paint, possibly creating hazardous conditions. DOE's policy is that Weatherization workers must be aware of the hazard and conduct Weatherization activities in a safe work manner to avoid contaminating homes with lead-based paint dust and debris, and to avoid exposing the occupants, themselves and their families to this hazard. The protocols used to safe guard people from lead-based paint hazards are called Lead Safe Weatherization.

a) Lead Safe Weatherization should be performed by Weatherization agencies when all of the following criteria are true:

(1) The dwelling was constructed pre-1978, and

(2) The dwelling has not been determined to be lead-based paint free, and

(3) Either, the amount of disturbed lead-based painted surface exceeds two square feet per room of interior surface, twenty square feet of exterior surface, or 10% of a small component type e.g., window; or the amount of lead-based paint dust that will be generated by the weatherization work exceeds the OSHA defined airborne levels for lead.

b) Lead Safe Weatherization protocol should include the following:

(1) Weatherization subgrantees will provide a copy of the pamphlet, "Protect Your Family from Lead in your Home", to inform the household of the potential risk of the lead hazard exposure.

(2) Subgrantees are required to have the client sign a form confirming receipt of the lead pamphlet.

(3) Weatherization workers are required to be trained in LSW. This training is an allowable use of DOE funds.

12. Additional Safety

a) Special precautions must be taken if the occupant of the home has respiratory ailments, allergies, is pregnant or has unique health concerns. Subgrantees should try and protect all clients from respirable particles, such as paint or insulation dust, during the weatherization process.

b) At minimum, auditors and crewmembers should inform property owners of safety problems, code problems and other health and safety issues. For problems that are life threatening or otherwise serious, the subgrantee supervisor should contact the jurisdiction having responsibility for the observed problem.

C. Required Subgrantee Walk-Away Policy

There are some situations in which a subgrantee should not or may choose not to weatherize an otherwise eligible unit. In order to deal with these situations each subgrantee must develop a policy which, when implemented, allows weatherization staff to "walk away" from conditions or circumstances that may be hazardous to their health and safety or that of the client's.

The following is a model walk-away policy intended to list the more common conditions and situations a subgrantee may encounter while delivering weatherization services. This list is not intended to be all inclusive of those instances in which a subgrantee may choose not to weatherize a unit. In some instances, corrective measures by the client/owner may allow program services to proceed. At a minimum, the subgrantee walk-away policy should contain the following:

1. Documentation

In the event a subgrantee cannot or chooses not to weatherize a dwelling unit it must notify the client and owner/authorized agent in writing and include the following items:

a) The nature and extent of the problem(s) and how the problem(s) relate to the determination to not weatherize the unit;

b) Any corrective action required before weatherization services can be initiated;

c) A time limit for correcting problems so that weatherization services may be rescheduled;

d) The right of appeal; and

e) All correspondence justifying the decision to "walk-away" must be kept in the client file.

2. Withholding of Weatherization Services

A subgrantee may withhold weatherization services under the following conditions:

a) A dwelling unit is vacant.

b) A dwelling unit is for sale.

c) A dwelling unit is scheduled for demolition.

d) A dwelling unit is found to have serious structural problems that would make weatherization impossible or impractical.

e) A dwelling unit is deemed by the auditor to pose a threat to the health or safety of the crew or subcontractor.

f) A mobile home is improperly installed (for example, inadequate supports).

g) A dwelling unit is uninhabitable (for example, such as a burned out apartment).

h) When there are minor children in the dwelling but no adult client or adult agent of the client, subgrantee personnel must not enter the dwelling.

i) An adult client or adult agent of the client need not be present if the estimator or crew foreman feels satisfied with a signed note from an adult client or adult agent of the client stating their permission to enter the dwelling occupied by the minor children.

j) The client is uncooperative with the weatherization subgrantee, either in demanding that certain work be done and refusing higher priority work which is needed, or by being abusive to the work crew or subcontractor, or by being unreasonable in allowing access to the unit, every attempt should be made to explain the program and the benefits of the work. If this fails, work should be suspended and the State Weatherization Office consulted.

k) Obvious discrepancies are found between the information supplied by the client on the application and observed conditions at the time of weatherization. The subgrantee must resolve these discrepancies before weatherization work can continue.

l) If, at any time prior to the beginning of work (materials installed in a unit), the subgrantee determines that the client is no longer eligible or subgrantee personal believe that circumstances may have changed, the unit shall not be weatherized until updated information can be obtained from the client.

m) There are rats, bats, roaches, reptiles, insects, animals or other vermin that are inappropriately or not properly contained on the premises.

n) There are health or safety hazards that must be corrected before weatherization services may begin including, but not limited to:

(1) The presence of animal feces and/or other excrement,

(2) Disconnected waste water pipes,

(3) Hazardous electrical wiring, or

(4) Unvented combustion appliances.

o) There are illegal drugs or illegal activities occurring on the premises.

p) The client or owner is physically or verbally abusive to subgrantee personnel.

q) The dwelling unit or parts thereof are being remodeled and weatherization work is not coordinated with a housing rehabilitation program.

r) The eligible household moves from the dwelling unit where weatherization activities and services are in progress. In such a case, the subgrantee must determine whether to complete the work and the circumstances must be documented in the client file.

s) There are unusual situations, which in the judgment of the subgrantee staff, must be corrected before proceeding with weatherization.

(1) No utility hookups (It is apparent that utilities have been shut off).

(2) Lack of cooperation from client.

(3) Dwelling units undergoing remodeling, or which have untreated areas that directly affect the weatherization process, shall not be weatherized.

t) If for any reason a worst-case draft test cannot be done in a dwelling requiring a worst-case draft.

II. Mechanical Systems & Combustion Appliances

All homes with combustion appliances shall be tested to determine if carbon monoxide levels exceed those recommended by the EPA, OSHA, and gas utilities. Combustion appliances include any appliance, water heater, wood stoves, furnace/heating system (including free standing kerosene, natural gas or propane space heaters) or lighting which has a flame or burns fuel in an open or enclosed chamber. Gas fired clothes dryers may be excluded from this requirement; however, the clothes dryer must be properly vented to the outside of the home. Except as noted, this includes all

active combustion heating systems and appliances whether they are primary, secondary, off-peak, or dual-fuel systems. Diagnostic equipment should be calibrated per manufacturers' instructions or as reasonably determined by the Weatherization Technical Workgroup.

The combustion appliance safety inspection includes all of the following: carbon monoxide test, draft measurement, spillage evaluation, and worst-case depressurization of the combustion appliance zone. Combustion safety test results must be acted upon appropriately according to the Combustion Safety Action Level Table. As applicable, every combustion appliance will be checked for a safe flue pipe, chimney or vent, adequate combustion air and gas leaks. Any unvented space heater must be properly vented or removed from the home before weatherization should proceed.

A complete mechanical systems audit is required on every home. All relevant information must be recorded on the Mechanical Systems Audit Form. The procedure includes collecting general information; interviewing the client; collecting and recording mechanical systems information; visual and diagnostic inspection of the venting and distribution system and combustion analysis and diagnostic tests for gas/oil-fired equipment. A post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope.

Whenever an appliance fails any of the combustion safety tests, appropriate repairs must be completed or specified in the weatherization work scope.

The following sections describe the actions that should occur on specific combustion systems to include additional safety tests, best practices and remedies for combustion related problems.

A. Gas Systems

Gas is the primary combustible fuel use in heating or appliance systems in Missouri homes. Natural gas and propane systems are basically the same differing only in the orifice sizes of their burners. The word “gas” used here means either natural or propane gas. The following inspection and maintenance practices should be performed on all gas-fired furnaces, boilers, water heaters and space heaters. The goal of the measures is to reduce carbon monoxide (CO), stabilize system combustion and test safety controls.

1. General Gas System Requirements & Best Practice

a) Gas leaks and piping problems should be checked at the beginning of the inspection process to ensure inspector and client safety before the appliance is run for testing. Testing should stop if a hazardous leak is detected. Any leak that can easily be smelled or sets off the alarm on a calibrated electronic gas leak detector is considered a hazardous leak and should be repaired before resuming the inspection process. Gas and piping procedures include the following:

(1) Test all accessible gas piping in the home for leaks using an electronic leak detector and/or soap bubbles. Electronically located leaks should be verified with soap bubbles. **All located leaks must be repaired**.

(2) Inspect the gas piping system for any potential hazards.

(3) If a flexible connector is badly kinked, corroded or shows signs of physical wear it should be replaced.

(4) Flex connectors of the soldered two-piece type or those manufactured in 1973 or before are to be replaced.

(5) Only American Gas Association (AGA) approved materials should be used in the gas piping system. This includes but is not limited to piping, fittings, valves and flex connectors.

(6) Only black iron pipe should be used as piping for natural gas systems.

(7) Black iron pipe, galvanized pipe or copper tubing can be used on propane systems.

(8) Inspect to make sure that flex connectors or soft copper tubing do not extend through a knockout hole into the cabinet of an appliance.

(9) Ensure that flex connectors are entirely in the same room as the appliance it serves and have a shot off valve on the inlet of the connector.

(10) Make sure that flex connectors used outdoors are rated for such use.

(11) Install sediment traps on systems that do not have them if the piping system is to be altered in any way.

(12) Make sure the piping system is properly supported.

(13) Repair any problems with the gas piping system.

b) Visually inspect for soot, burned wires and other evidence of flame roll-out.

c) Inspect the burners for dust, debris, misalignment, and other flame-interference problems.

d) Inspect the heat exchanger for leaks using the following methods:

(1) Visually inspect the heat exchanger, shining a bright light on one side and looking for light traces on the other using a mirror to peer into tight locations. Observations of rust at exhaust ports and at the vent connector and flame impingement on the heat exchanger during firing are red-flags for heat exchanger problems.

(2) Observe flame movement, change in chimney draft, or change in CO reading as blower is turned on and off.

(3) To test for cracks using a combustion analyzer, simply watch the O_2/ CO_2 readings and the CO reading when the blower comes on - usually several minutes after the burner(s) ignite. Typically, the O_2/ CO_2 or CO readings will stabilize within 30 to 60 seconds after ignition. If a crack is present, when the blower energizes, air (at 20.9% O_2) may be blown through the crack in sufficient quantities to raise the O_2 (or decrease the CO_2) reading on the combustion analyzer. Repeat this procedure to ensure conclusions.

(4) Employ chemical detection techniques, following manufacture's instructions.

(5) Use techniques recommended by the Gas Appliance Manufacturer's Association (GAMA).

Action: any primary heating system with a cracked heat exchanger must be replaced if weatherization is to proceed on the home. Non-primary systems should be removed from the home when practical.

e) Assure that all 120-volt wiring connections are enclosed in covered electrical boxes. Furnaces and boilers should have dedicated circuits.

f) Determine that pilot is burning (if equipped) and that main burner ignition is satisfactory.

g) Sample the undiluted combustion gases (before draft diverter and may require multiple tests in multi-cell exchanger) with a calibrated flue-gas analyzer during operation.

h) Test pilot safety control for complete gas valve shutoff when pilot is extinguished.

i) Check the thermostat's heat-anticipator setting. The setting should match the measured current in the 24-volt control circuit.

j) Check venting system for proper size and pitch. See NFPA 54 – Fuel Gas Code for reference.

k) Check venting system for obstructions, blockages, or leaks.

l) Measure chimney draft downstream of the draft diverter.

m) Test to ensure that the high-limit control shuts-down the system when temperature rises within 10 percent of 200 degrees Fahrenheit.

n) Measure gas input, and observe flame characteristics if soot, CO, or other combustion problems are present. Clocking a meter, if applicable, is an appropriate indicator for determining if more precise measurement is necessary.

Action: a clean and tune and appropriate repairs should be included in the weatherization work scope when CO is greater than 100 ppm, visual indicators of soot or flame roll-out exist, burners are visibly dirty, measured draft is low or nonexistent, the appliance has not received regular service for two or more years or the auditor determines such is appropriate to ensure safe and efficient operation.

2. Combustion Appliance Zone (CAZ) Test

A combustion appliance zone is any space where a vented combustion appliance is located. The CAZ must be measured for worst-case depressurization. The worst-case depressurization test is configured by determining the largest combustion appliance zone depressurization due to the combined effects of door position, exhaust appliance operation, and air handler (generally the furnace blower) fan operation. A base pressure must be measured with all fans off and doors open. The worst-case depressurization is the pressure difference between worst-case and the base pressure.

A recommended protocol for completing all of the combustion safety tests for vented appliances follows. This step-by-step procedure is recommended to guide technicians through a complete combustion safety analysis safely and efficiently:

a) **Measure the base pressure**. Start with all exterior doors and windows closed and the fireplace damper closed. Set all combustion appliances to the pilot setting or turn off the service disconnect. Combustion appliances include boiler, furnace, space heaters, and water heater. With the home in this configuration, measure and record the baseline pressure of the mechanical room WRT outside.

b) **Establish the Worst Case**. Turn on the dryer and all exhaust fans. Close all interior doors that do not pull air from the mechanical room. Turn on the air handler, if possible, and if the pressure in the CAZ becomes more negative, then recheck the door positions. Measure the net change in pressure from the mechanical room to outside, correcting for the base pressure. Record the "worst case depressurization" and compare to Table III-4 – CAZ Depressurization Limit.

c) **Measure Worst Case Spillage, Draft, CO**. Fire the appliance with the smallest Btu capacity first, test for spillage at the draft diverter with a flame or smoke test, and test for CO before the draft diverter at 5 minutes of burner operation. If spillage occurs under the worst-case condition go on to the step d) below. If no spillage is found, test the draft in the connector 2' after the diverter or first elbow and fire all other connected appliances simultaneously and test the draft diverter of each appliance for spillage. Test for CO in all appliances before the draft diverter.

d) **Measure Spillage, Draft, CO under Natural Conditions**. If spillage is found in the first draft hood at worst case, turn off the exhaust fans and open the interior doors with the first appliance operating and test again for CO, spillage, and draft under "natural conditions". Measure the net change from worst case to natural in pressure from the CAZ to outside to confirm the "worst case depressurization" taken in step b). Repeat the process for each appliance, allowing the vent to cool between tests.

Note: Vent pressure should be measured at steady-state operating conditions (generally after 5 minutes of run time and distribution fan operating when applicable) for all natural draft heating and hot water appliances. Draft test location should be approximately 1-2 feet downstream of the appliance draft diverter. The test hole must be sealed with an appropriate plug after the test. Acceptable draft test results are in the table below:

Table III-1

Acceptable Draft Test Ranges	
Outside Temperature (degree F)	**Draft Pressure Standard (Pa)**
<10	-2.5
10-90	(T_out / 40) – 2.75
>90	-0.5

Note: Most appliances will spill upon startup with a cold chimney. Document the amount of time it takes for spillage to stop and a draft to be established. Any appliance that continues to spill flue gases beyond the time limits established in the table below has failed the spillage test.

When a chimney is shared by multiple appliances, the appliance with the smallest Btu input rating should be tested first and remaining appliances tested in order of increasing input rate. Induced draft heating systems should be checked for spillage at the base of the chimney liner or flue. If a chimney is shared between an induced draft heating system and a natural draft water heater, spillage should be checked at the water heater draft diverter.

Table III-2

Acceptable Appliance Spillage Periods	
Appliance Type	**Spillage Test Period (minutes)**
Water Heater, Gravity Furnace, Boiler	1.0
Space Heater	1.0
Forced Air Furnace	1.0

e) Ambient CO. Monitor the ambient CO in the breathing zone during the test procedure and abort the test if ambient CO goes over 35 ppm. Turn off the appliance, ventilate the space, and evacuate the building. The building may be reentered once ambient CO levels have gone below 35 ppm. The appliance must be repaired and the problem corrected prior to completing the combustion safety diagnostics. If the ambient levels exceed 35 ppm during testing under natural conditions, disable the appliance and instruct the homeowner to have the appliance repaired before operating it again or include the repair in work scope if weatherization services are provided.

f) Action Levels. Make recommendations or complete work order for repairs based on test results and the Combustion Safety Test Action Level Tables.

Table III-3

Combustion Safety Test Action Levels			
CO Test Results*	**And /Or**	**Spillage & Draft Test Results**	**Retrofit Action**
0–25 ppm	*And*	**Passes**	Proceed with work
26-100 ppm	*And*	**Passes**	Recommend the CO problem by fixed
26-100 ppm	*And*	**Fails at worst case only**	Recommend a service call for the appliance and/or repairs to the home to correct the problem.
100-400 ppm	*Or*	**Fails under natural conditions**	Stop Work: Work may not proceed until the system is serviced and the problem is corrected
>400 ppm	*And*	**Passes**	Stop Work: Work may not proceed until the system is serviced and the problem is corrected
> 400 ppm	*And*	**Fails under any condition**	Shut off fuel to the appliance and make arrangements to service the appliance immediately

**CO measurements for undiluted flue gases*

g) When CAZ depressurization limits are exceeded under worst-case conditions according to the CAZ Depressurization Limit table, make up air must be provided or other modifications to the building shell or exhaust appliances must be included in the work scope to bring the depressurization within acceptable limits. Worst-case CAZ depressurization limits are shown in the table below:

Table III-4

CAZ Depressurization Limits	
Venting Condition	**Limit (Pascals)**
Orphan natural draft water heater (including outside chimneys)	-2
Natural draft boiler or furnace commonly vented with water heater	-3
Natural draft boiler or furnace with vent damper commonly vented with water heater	-5
Individual natural draft boiler or furnace	-5
Induced draft boiler or furnace commonly vented with water heater	-5
Power vented or induced draft boiler or furnace alone	-15
Exhaust to chimney-top draft inducer; high static pressure flame retention head oil burner; direct vented appliances; sealed combustion appliances	-50

3. Forced Air Systems

Forced air systems are the most common type of heating system. Leaky ducts and airflow are common problems with heating systems. A gas system should receive maintenance services every 2 to 4 years and are often neglected in low-income homes thereby creating inefficient and unsafe systems. Additional diagnostics and actions to remedy problems with such systems are described below.

a) Measure heat rise after 5 minutes of operation. Heat rise is supply air temperature minus return air temperature. The heat rise should be between 40 degrees F and 70 degrees F with the lower end of this range being preferable for energy efficiency. Manufacturers' recommendations should be followed when practical to obtain.

b) Forced air systems should be a closed duct system, meaning the supply air and return air should only be delivered and returned from the intentionally heated areas of the house. Air intentionally entering the return system from an unheated area of the house is not acceptable.

c) The fan-on temperature should be less than 140 degrees F.

d) The fan-off temperature should be between 95 and 105 degrees F, with the lower end of the scale being preferable for maximum efficiency.

e) The high-limit safety control should shut the burner off before the furnace temperature reaches 200 degrees F.

f) On time-activated fan controls, verify that the fan is switched on within two minutes of burner ignition and is switched off within 2.5 minutes of the end of the combustion cycle.

4. Hydronic System Standards

The following standards refer to hydronic systems commonly found in single family homes. Hydronic systems found in multi-family buildings are generally more complex and should be tested and evaluated by professionals experienced in their operation. Observe the following standards for servicing hydronic heating systems in single family structures.

a) Hot Water Space-Heating

Hot water heating is generally a little more efficient than forced-air heating and considerably more efficient than steam heating. The most significant energy wasters are off-cycle flue losses stealing heat from stored water and operating at too high a water temperature. Boilers are more dangerous than furnaces, so checking their limit controls and pressure tank are important safety procedures. Consider the following safety and efficiency checks for potential improvements:

(1) Check operation of a 30-psi-rated pressure-relief valve and replace or add one if necessary. Note signs of leakage or discharges and find out why the relief valve is discharging.

(2) Check for leaks on the boiler, its fittings or on any of the distribution piping connected to the boiler. High-limit control should deactivate boiler at 200° F or less.

(3) Make sure that the pressure tank isn't waterlogged This could cause pressure-relief valve discharge. Test pressure tank for its rated air pressure – often 15 psi.

(4) Lubricate circulator pump if necessary.

(5) Repair water leaks in the system.

(6) Boiler should not have low-limit control for maintaining a minimum boiler-water temperature, unless the boiler is heating domestic water in addition to space heating.

(7) Bleed air from radiators and piping through air vents in elbows or radiators. Most systems have an automatic fill valve. If there is a manual fill valve for refilling system with water, it should be open to push water in and air out, during air purging.

(8) Consider installing electric vent dampers on atmospheric gas- and oil-fired high-mass boilers to prevent significant heat loss up the vent stack.

(9) Consider installing reset controllers on larger boilers to regulate water temperature, depending on outdoor temperature.

(10) Clean fire side of heat exchanger of noticeable dirt.

(11) Vacuum and clean fins of fin-tube convectors if you notice dust and dirt there.

(12) Verify that all hot water boilers have a pressure tank to control pressure and prevent system damage from water's expansion.

(13) Insulate all supply piping, passing through unheated areas, with foam pipe insulation, at least one-inch thick, rated for temperatures up to 200° F.

b) Steam Heating

Steam heating is less efficient than hot water heating because a steam boiler heats water to its boiling point before making any steam or doing any space heating. Higher

temperature heating systems are less efficient than lower temperature ones. Steam boilers are also more hazardous because of the steam pressure. For these reasons heating-system replacement with a hot-water or forced-air system should be considered.

If the steam-heating system must remain, operate it at the lowest steam pressure that will heat the building. This may be near 0 psi on the boiler pressure gauge. Large buildings need higher steam pressures but smaller ones can operate at little or no measurable steam pressure. Traps and air vents are crucial to operating at a low steam pressure. Electric vent dampers will reduce off-cycle losses for both gas- and oil-fired systems. Perform the following safety checks and efficiency checks for possible improvement regarding steam systems:

(1) Steam boilers should be equipped with high-pressure limits and low water cut off controls. Verify that high-pressure limit control is set at or below 10 psi.

(2) Verify that flush valves on low-water cutoffs are operable and do not leak.

(3) On steam boilers with externally mounted low-water cut off, verify the function of the control by flushing the low-water cutoff with the burner operating. Combustion must cease when the water level in the boiler drops below the level of the float.

(4) Verify steam vents are operable and that all steam radiators receive steam during every cycle. Unplug vents as necessary. Add vents to steam lines and radiators as needed to achieve this goal.

(5) Check steam traps with a digital thermometer or listening device to detect any ' steam escaping from radiators through the condensate return. Replace leaking steam traps or their thermostatic elements. Repair leaks on the steam supply piping or on condensate return piping.

(6) Consider a flame retention burner and electric vent damper as retrofits for steam boilers.

(7) Clean fire side of heat exchanger of noticeable dirt.

(8) Drain water out of blow-down valve until water runs clear.

(9) Check with owner about chemicals added to boiler water to prevent corrosion. Add chemicals if necessary.

(10) All steam piping, passing through unconditioned areas, should be insulated to at least R-3 with insulation rated for steam piping.

5. Gas Range and Oven

Gas range cook tops and ovens are often significant generators of CO in a kitchen. Frequent causes of CO production are from over firing, dirt buildup and foil installed around the burners. Ovens are prone to produce CO regardless of condition. The following tests and recommended actions are relevant to gas range and oven safety:

a) Although not required, it is recommended to test each stove-top burner separately using a digital combustion analyzer or CO meter and holding the probe about 8 inches above the flame for 2 minutes.

Action: Clean and adjust burners producing more than 25 ppm. Burners often have an adjustable gas control or orifice.

b) See the table below for oven testing instructions and action levels.

Natural Gas or Propane Ovens*

1. Remove any items / foil in or on oven.
2. Make sure self-cleaning features are not activated, set oven to highest setting.
3. Test oven for CO in the oven vent, before dilution air.
4. After 5 minutes of operation, check for steady state. Record steady state CO reading and the ambient air: • If > **50 ppm** in oven vent the appliance should be serviced. • If ambient is >= **35 ppm** shut down the appliance until repairs are made.
5. In the event the oven continues to produce > **50 ppm** after servicing, the following options are available: • Inform the occupant of the CO reading and of the safety concern. • Install exhaust ventilation with a capacity of 25 CFM continuous or 100 CFM intermittent. (best practice) • Properly locate and install an approved CO alarm. • Consult with State Weatherization Director for approval to replace the unit.

** Continually monitor ambient CO levels during the test.*

6. Gas Dryers

Gas dryers are generally not significant producers of CO when the burner is firing. No specific tests are required. The Weatherization auditor may conduct any appropriate tests that could remedy a safety concern. The following items are relevant to safe gas dryer operation and should be corrected as necessary:

a) Gas dryer vents must always be vented directly to the outdoors, that is, not terminated in an attic or crawlspace.

b) Gas dryer vent pipe should not be installed with sheet metal screws or other intrusive fasteners that will collect lint and block the vent gases.

7. Domestic Water Heaters

In addition to the general gas combustion system requirements described above, gas fired water heaters must meet the following specifications:

a) A water heater must have a pressure and temperature relieve valve and a safety discharge pipe. Either should be installed if not present. The discharge pipe should terminate 6 inches above the floor or outside the dwelling or as specified by local codes. The discharge should be made of rigid metal pipe or approved high temperature plastic pipe.

b) Water heaters should be insulated to at least R-10 with an external insulation blanket, unless the water heater label gives specific instructions not to insulate, the water heater is already insulated properly, or the water heater is located in conditioned space.

c) Water heater insulation must not obstruct draft diverter, pressure relief valve, thermostats, plumbing pipes, or thermostat access plates.

d) Inspect the water heater for health and safety hazards. A water heater lacking a pilot access door, if applicable, a pressure and temperature relief valve or discharge pipe shall be considered a health and safety issue. Water heaters shall be inspected for adequate combustion air and a safe and proper flue gas venting system (refer to the National Fuel Gas Code – NFPA 54).

e) Water heaters that cannot be economically repaired may be replaced as a health and safety measure. Replacements will be limited to owner-occupied units. Rental units that have an unsafe water heater will not be weatherized until the landlord has installed an approved, safely operating water heater. Replacement is limited to natural gas, propane and oil-fired systems. Replacement water heaters shall be installed according to manufacturer's specifications and local, state and federal codes.

B. Oil Systems

1. General Information

Oil-fired furnaces, boilers or water heaters are not encountered frequently in the Missouri Weatherization Program. In addition, oil burners require annual maintenance to retain the

desired operation, efficiency and safety characteristics. In consideration of the limited encounter with oil systems, the following tests and best practices should be considered to achieve a minimum standard or oil burner safety:

a) Inspect fuel lines and storage takes for leaks and repair all identified leaks as appropriate.

b) Inspect burner and appliance for signs of soot, overheating, fire hazards, or wiring problems.

c) Assure that all 120-volt wiring connections are enclosed in covered electrical boxes. Each oil furnace or boiler should have a dedicated electrical circuit.

d) Inspect heat exchanger and combustion chamber for cracks, corrosion, or soot buildup.

e) Inspect to see if flame ignition is instantaneous or delayed. Flame ignition should be instantaneous except for units where the blower runs for a while to purge the system before ignition.

f) Sample undiluted flue gases with a smoke tester following the smoke-tester instructions. Compare the smoke residue left by the gases on the filter paper with the manufacturer's smoke-spot scale to determine smoke number.

g) Analyze the flue gas for O_2 or CO_2, temperature, CO, and steady-state efficiency. Sample undiluted flue gases between the barometric draft control and the appliance.

h) Measure flue draft between the appliance and barometric damper draft control. The measured draft should range from -15 Pascals at less than 20 degrees outside temperature to –7 Pascals at greater than 80 degrees outside temperature.

Action: Additional testing beyond that stated above and necessary repairs to correct identified problems should be referred to a heating technician experienced with oil systems to assure proper maintenance.

Action: Auditors who have not received appropriate training or have had limited experience with oil systems enabling them to conduct the limited tests above should contact the Missouri Weatherization staff to determine appropriate actions to assure a safe and efficient system. **Weatherization should not proceed until a safe system is assured.**

C. Wood-Solid Fuel Systems

1. Wood/Coal Stoves and Fireplaces

a) Whenever possible, ask the client to start the wood or coal stove after the use of any blower door testing has been completed. With the stove operating, check around the

solid-fuel appliances for carbon monoxide (CO) emissions. If there are any indications of CO leaking from the stove into the ambient air repairs should be made to correct the problem. Weatherization should not proceed until appropriate repairs are made allowing safe operation of the stove or fireplace.

b) All venting systems and installations shall comply with the latest edition of NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances*.

c) The client shall be notified of any unsafe conditions.

D. Combustion Air Supply

1. Atmospheric Combustion Appliances

a) Combustion appliances need a source of combustion air while they are operating. If the CAZ contains or is properly connected with less than a volume of 50 cubic feet of indoor space for every 1,000 Btu of appliance input rating, it is defined as a "confined space" by the National Fire Protection Association (NFPA). In this case, steps must be taken to correct the situation. Please refer to the latest edition of NFPA 31, *Standard for the Installation of Oil-Burning Equipment*; NFPA 54, *National Fuel Gas Code*; or NFPA 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances* for corrective measures.

b) If the CAZ contains or is properly connected with a volume of 50 cubic feet or more of indoor space for every 1,000 Btu of appliance input rating, it is defined as an "unconfined space" by the National Fire Protection Association (NFPA). In this case, no corrective action is required, unless an appliance in the CAZ fails the worst-case draft test.

c) Modern weatherization techniques can create a situation referred to by the NFPA as unusually tight construction. When this situation occurs, the whole house may not supply adequate combustion air to assure complete combustion and proper draft of appliances. This situation will be detected by the post blower door test for Building Airflow Standards and the post CAZ test. Remedies for this situation may include power venting, mechanical ventilation, exhaust fans and other methods referenced by the above sited NFPA methods for introducing combustion air. In as much as possible, tightening a home beyond the Building Airflow Standards should be avoided.

2. Direct Vent and Combustion Air

a) Many new combustion appliances are designed for direct out-door-air supply to the burner. These include most condensing furnaces, mobile home furnaces, mobile home water heaters, many space heaters, and some non-condensing furnaces and boilers. Some appliances give installers a choice between indoor and outdoor combustion air. Outdoor combustion air is usually preferable in order to prevent the

depressurization problems, combustion-air deficiencies, and draft problems common in atmospheric, open-combustion systems.

b) The dedicated combustion-air intake of sealed combustion (direct-vent) appliances must be inspected. The air intake must be physically connected to the appliance body and it must pull air from outside the building structure when intended to do so.

E. Heating System Replacement

Replacements will be limited to owner-occupied units. Rental units that have an unsafe heating system will not be weatherized until the landlord has installed an approved, safely operating heating system. Replacements will be limited to natural gas, propane and oil-fired systems. Electric heating systems are not eligible for replacement. A site-specific heating system replacement may be authorized by DNR/EC on a case-by-case basis.

Heating appliances are often replaced when the cost of repairs, retrofits or a combination of both exceed two thirds of estimated replacement costs. The replacement cost must, of course also be within the budget of the job as determined by an agency's policies and decision-making tools like NEAT. Moreover, the cost of replacement must have an Savings to Investment Ratio (SIR) of one or greater or the replacement must be reported under health and safety. In some instances, it may be necessary for the heating contractor to repair a heating appliance before it can be tested. Estimate the repair and retrofit costs and compare them to replacement cost before proceeding. Heating systems with a crack in the heat exchanger must be replaced.

New heating appliances must be installed to manufacturer's specifications, following all applicable building and fire codes. Replacement gas furnaces with higher Annual Fuel Utilization Efficiency (AFUE) of 90% may be considered if agency cost limits will allow. These direct vent systems may be an installation option when choosing a direct vent model will remedy an installation issue with building design or safety.

Non-electric primary heating appliances that are not operational and/or not repairable may be replaced. To determine the steady-state efficiency for a system that is not operational, divide the input rating by the output rating on the nameplate for a reasonable efficiency estimate. The heating appliance may also be replaced if the current system is a gravity furnace or boiler, converted from coal and the SIR is calculated at one or greater to include all costs associated with replacement, including removal of the old system. If the heating system is a converted system, the nameplate is not readable or is not present, a steady-state efficiency of 57 percent may used to calculate the SIR.

Sizing calculations should meet general HVAC sizing calculations such as Manual J or approved computerized load calculations. Sizing should account for lower heating loads resulting from insulation and air-sealing work.

The assumption that older furnaces and boilers are inefficient should not be made until testing them. Before deciding to replace a heating system, every effort to repair and retrofit it should be made. Replacement parts like gas valves and controls for older heating units are commonly

available. Repair is defined as any work needed to bring heating appliance up to manufacturer's specifications for safe and efficient operation. Repair items include replacing blower motors and pumps, fixing vent connectors and chimneys, or other activities required to bring heating appliance up to safe and operable condition.

F. Heating System Modifications

Allowable retrofits or modifications include flame retention burners, intermittent (electronic) ignition devices, automatic vent dampers and thermally actuated vent dampers.

G. Mobile Home Systems

There are many characteristics common of mobile home heating systems and those generally installed in site-built structures. The general test procedures for gas or oil should be followed as described above. There are some differences that need recognition for proper testing and operation.

1. General Characteristics

a) Mobile home combustion systems have been sealed combustion systems since the early 1970s, in that the air for combustion comes from outside the conditioned space and vent gases move the combustion products to the outside air.

b) Gas furnaces are either the older atmospheric sealed combustion type or the newer fan-assisted mid-efficiency models, however, some older less-efficient models had draft fans too.

c) The majority of mobile home systems will be down flow furnaces, designed specifically for mobile homes.

d) Mobile home systems are sealed-combustion systems that use outdoor combustion air. The systems do not have draft diverters or barometric draft controls. At times it is necessary to remove wall panels or portions thereof to gain access to the vent pipe to sample the flue gas and test for draft. Many mobile home systems are two wall venting systems with combustion air entering the system through the outer wall channel and the vent gas exiting through the inner passage. When this is the case, care must be taken to ensure both drill holes are sealed following the test of the combustion system.

e) Gas-fired systems for mobile homes generally come with kits allowing conversion between natural gas and propane. The weatherization auditor should be alert to the possibility of the wrong orifice installed in the system.

f) Return air is generally admitted to the furnace through a large opening in the furnace rather than through return ducts.

2. System Repair or Replacement

a) Mobile home furnaces must be replaced by furnaces designed and listed for use in a mobile home.

b) Mobile home furnaces may be replaced when any of the following is observed:

(1) The furnace has a cracked heat exchanger. There are some models that will allow replacement of the heat exchanger. The replacement may be considered when determined by the agency to be safe and cost-effective.

(2) Repair and retrofit exceed half of the replacement cost.

(3) The furnace is not operating and not repairable.

c) The following additional items should be considered regarding replacement:

(1) Follow manufacturer's installation instructions carefully.

(2) Make sure the furnace base exactly matches the new furnace or allow for a new base.

(3) The furnace base should be attached firmly to the duct and all seams sealed between the base and the duct with mastic and fabric tape before installing the furnace.

(4) Provide any additional support underneath the furnace with additional strapping or other material that will provide the support as necessary.

(5) Make sure any difference in the method of supplying combustion air is accounted for.

(6) Install a new chimney that is manufactured specifically for the new furnace.

(7) In the event the new chimney does not exactly line up, use an offset pipe provided by the manufacturer for this purpose or cut enlarge the opening to allow the new chimney to remain vertical.

(8) Properly install the vent cap.

III. Shell & Duct Air Leakage Diagnostics

A. Blower Door Testing & Diagnostics

The blower door is highly valued as a weatherization tool as it can be used to determine the pre- and post-weatherization dwelling leakage rates. The pre-test should aid the auditor in

determining the air sealing work scope with the post-test providing an accurate idea of the effectiveness of the air sealing efforts and to assure the building tightness is satisfactory. In addition, the blower door is used for zone pressure testing and duct leakage testing to aid building diagnostics.

In order to obtain consistent test results, it is important the blower door is setup and used properly at each weatherization job. The depressurization blower door test is preferred by Missouri's Weatherization Assistance Program because it takes less time to perform than a pressurization test and it is the standard test used in the low-income weatherization program across the U.S. However, the pressurization test is an acceptable alternative when conditions warrant its use.

Pre and post weatherization blower door tests are required actions. Exceptions to this requirement should be minimal and thoroughly documented in the client file.

1. Preparation for Blower Door Test

The blower door testing procedures below assumes the use of The Energy Conservatory (TEC) Minneapolis Blower Door, Model 3, with the companion TEC analog magnehelic gauges or the TEC digital manometer, Model DG-3. The Minneapolis Blower Door Operation Manual should be referenced for additional information.

a) Subgrantees should maintain accurate calibration of blower doors and related equipment. This includes:

(1) Blower door fan.

(a) There should be no physical damage to the fan.

(b) The flow sensor on the Minneapolis Blower Door, Model 3, is the white ring that is permanently attached to the end of the motor opposite the fan blade. The ring is perhaps the most critical part of the Blower Door fan. Make sure the sensor is in its proper position, not damaged, that the connected hose is in good condition, and that the four holes in the sensor are not obstructed or blocked.

(2) If there is a problem with the fan or the flow sensor, contact the manufacturer before further use.

(3) Magnehelic gauges (round with needle indicators) should be calibrated once every five years by the manufacturer.

(4) Digital pressure gauges should be calibrated annually by the manufacturer.

(5) For detailed maintenance recommendations for equipment manufactured by The Energy Conservatory, go to http://www.energyconservatory.com/manuals.html and download Maintenance Tips.

b) Deactivate all vented combustion-type appliances before depressurizing the structure by turning the thermostat down or the appliance off.

c) Prevent the ashes of wood/coal burning units from entering the living space by closing/sealing doors and dampers or by cleaning out or covering the ashes.

d) Inspect the house for loose or missing hatchways, paneling, ceiling tiles, or glazing panes. Secure any items that may become dislocated during the test and seal any missing hatchways.

e) Close all prime windows, self-storing storm windows (if possible), sky lights, and exterior doors and latch them, as they normally would be found during the winter.

f) Open all livable areas to the interior of the structure, even if the occupants close them off during the winter.

g) Close basement doors during test unless one or more of the following conditions is present:

(1) The basement is used as a living area.

(2) The client leaves the basement door open during the winter or there is no basement door.

(3) The air returns do not connect directly to the furnace.

h) Set up the blower door unit in a favorable location in an area free from obstructions and wind interference.

2. Blower Door Depressurization Test (preferred)

a) Set the blower door up in an exterior door with the least number of obstacles within 3 feet of the blower door fan. If the doorway leads to an enclosed area, make sure the space is open to the outdoors. Do not set up in a door facing the wind if an acceptable alternative exists.

b) Install the frame and panel securely into the doorframe, making sure that there are no gaps between any of the components or between the components and the doorframe

c) Set the fan into the panel/frame assembly, making sure that the panel opening fits nugly around the fan. Install the fan so that the flow ring assembly (or low flow

plate) is facing toward the inside of the house. Set up the fan in a level or nearly level position.

d) Set up the gauges in a vertical position if using the magnehelic or digital gauges.

e) Make sure the variable speed control is in the off position. Plug the fan electric cord into a safe and fully functional electrical outlet.

f) Insert the tube from the house pressure gauge into the hole in the door panel. Make sure that the end of the hose is not in front of the fan outlet or positioned so that it is exposed to windy conditions. Leave the fan pressure gauge tube end inside the house (not connected to the fan). Ensure that the fabric cover or all the rings and the center plug are on the fan.

(1) If you are using the magnehelic gauges, zero all three of them.

(2) If you are using a digital manometer, record the background pressure reading. This reading is usually a result of stack pressure. When you depressurize the house with the blower door, make sure to bring the house to a pressure that is 50 Pascals less than this background pressure. For example, if the background pressure is -3 Pascals, depressurize the house to -53 Pascals. If the background pressure is -5 Pascals, depressurize the house to -55 Pascals. Install the open end of the fan pressure gauge tube onto the blower door fan pressure tap.

g) Perform a one-point test by depressurizing to -50 Pascals house pressure or the highest house pressure if unable to reach -50 Pascals. Use the flow rings or low-flow plate if the fan pressure is less than 20 Pascals. If wind seems to be affecting test results, take several one-point tests and average the results.

h) Calculate the CFM50 of the dwelling by using the markings on the magnehelic gauges, digital gauges, or the blower door tables.

3. Blower Door Pressurization Test

a) Use the pressurization blower door test method only if a solid fuel heating unit or for some other reason approved by the Missouri Weatherization Program.

b) Install the door panel and hang the gauge assembly, as it normally would be installed.

c) Attach a tube to the lower tap of the house pressure gauge and run the other end of the tube through the hole in the upper part of the door panel making sure it is away from the fan outlet. See the digital manometer instructions for the proper hose connection for house pressurization.

d) Leave the fan pressure tube “tee” attached to the gauges and fan, as it normally would be for a depressurization test.

e) Attach an extra "tee" to the upper taps of the fan pressure gauge and run the other end of the tube to the outside of the house, somewhere away from any fan turbulence.

f) Install the fan with the flow rings/low-flow plate attaches should be facing the outdoors. The fan tube and the extra tube will run outside between the fan housing and the elastic collar. The fan speed control must remain on the inside of the door panel.

g) Level and stabilize the fan as necessary.

h) Do not change the fan directional switch from its normal (forward) position.

i) Zero the gauges according to the blower door manual.

j) Perform a one-point test by pressurizing to -50 Pascals house pressure or the highest house pressure if unable to reach -50 Pascals. Use the flow rings or low-flow plate if the fan pressure is less than 20 Pascals. If wind seems to be affecting test results, take several one-point tests and average the results.

k) Calculate the CFM50 of the dwelling by using the markings on the magnehelic gauges, digital gauges, or the blower door tables.

B. Blower Door Guided Air Sealing

1. Pre-Guideline and Guideline Air Sealing

Air sealing work is best performed with the use of the blower door to focus the work in the most cost-effective area. Agency crews and contractors are expected to make use of the blower door as a valuable tool and shall make every reasonable effort to incorporate blower door guided air sealing strategies into their weatherization services.

Air sealing work on dwellings consists of the following categories:

a) *Pre-guideline air sealing.* Examples include replacing window glass where glass is missing and sealing gross holes in the building envelope. There is little question that sealing or repairing these gross holes in the dwelling envelope will be cost-effective.

(1) Prior to any work done on the dwelling, an "as-is" blower door test should be performed as a means of finding these gross holes. This test will indicate whether pre-guideline air sealing is required in order to perform a more representative blower door test.

b) *Guideline air sealing.* This is air sealing completed with the guidance of the Air Sealing Cost-Effective Guidelines (ASG). The ASG must be used on all blower door

guided air sealing. As with other measures, air sealing work is cost-effective only up to a point. Once that point is reached, air sealing work on a dwelling should cease. Agencies are expected to use their experience and expertise to control the air sealing costs and assure the CFM_{50} reduction is cost-effective.

c) *Estimating leakage areas*. There are several ways to convert blower door CFM_{50} measurements into square inches of total leakage area. The simplest way to convert CFM_{50} into an approximate leakage area (ALA) is to divide CFM_{50} by 10. The ALA can help you visualize the size of openings you're looking for in a home or section of a home. The formula is: **$ALA = CFM_{50} \div 10$.**

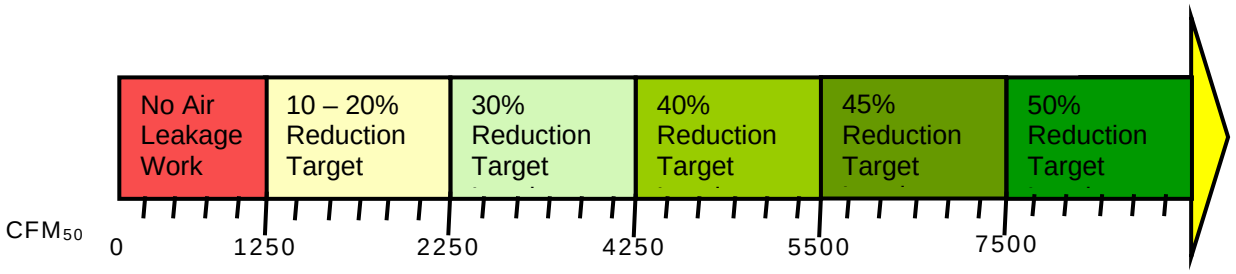
C. Weatherization Cost-Effective Guidelines

This following ASG should be used to guide the level of air sealing and serve to aid in the estimation of cost-effective air sealing. The value of the air sealing activity is relevant to the cost of obtaining the CFM_{50} reduction in relation to the cost of heating/cooling fuel. The primary focus of the Missouri Weatherization Program is on air sealing to reduce heating costs. For the guideline described below, a statewide average gas price is used to evaluate the savings from CFM_{50} reduction and is an acceptable approach. Higher or lower fuel costs would alter the outcome of the Savings to Investment Ratio (SIR) of the air sealing work. Agencies desiring to obtain more accuracy in their air sealing work are recommend to purchase the Techtite Software program distributed by The Energy Conservatory.

1. Procedure

a) Air sealing should prioritize big holes first, then attic, then basement, then windows/doors/interior).

b) To estimate the potential for air sealing, refer to the graphic below:



c) By applying some basic assumptions and using the Techtite Software, 100 CFM_{50} reduction is valued at $5.50 in heating savings per year. An SIR of one (1) would allow an air sealing cost for material and labor of $82.50 to be expended for each 100 CFM_{50} of reduction. Agency staff must consider the impact of air sealing, along with other energy saving measures on the cumulative SIR of one (1) requirement. For example, if the client home is in need of incidental repair, the air sealing may need to focus on the low cost higher reduction areas to raise the air sealing SIR and help meet the cumulative requirement. Air sealing inputs for the National Energy

Audit (NEAT) should be consistent with this air sealing guideline with actual air sealing costs and CFM_{50} reductions compared with estimates on a regular basis to ensure a reasonable level of accuracy. The basic assumptions for the air sealing guideline are as follows:

(1) One story home at 1,500 square feet.

(2) Surface area of 4,280 representing a crawlspace foundation.

(3) House volume of 12,000 cubic feet.

(4) Three bedrooms, 4 occupants.

(5) Heating fuel cost of $10.10 per million Btus.

(6) Fifteen year life of the air sealing measures.

(7) Pre-blower door test at 1,330 CFM_{50}.

(8) Post-blower door test at 1,330 CFM_{50}. (This assumption is based on the calculated minimum Building Airflow Standard.)

d) Therefore, using the above assumptions, the air sealing SIR is calculated as $5.50 times 15 equals $82.50 for a SIR of one (1). To improve the SIR, less must be expended for each 100 CFM_{50} reduction. For example, to improve the SIR to three (3), the cost of achieving a 100 CFM_{50} reduction must be $27.50. That is $5.50 times 15 equals $82.50 divided by 3 equals $27.50.

e) When the strategy for air sealing costs more than the amount necessary to meet the desired SIR, the air sealing should stop unless there are documented reasons to continue such as health and safety issues or potential for damage to the structure.

D. Building Airflow Standard

The purpose of the Building Airflow Standard (BAS) is to ensure that the dwelling complies with the ASHRAE Standard 62-1989, *Standard for Acceptable Indoor Air Quality*. This Standard requires at least 15 cfm of fresh outdoor air per person and 0.35 air changes per hour per dwelling unit. **The BAS must be calculated for each dwelling and should be determined before weatherization work begins.**

The BAS is converted to a CFM_{50} value, using the Building Performance Institute's abbreviated Lawrence Berkeley Laboratory conversion method. The conversion to CFM_{50} makes the determination of whether the dwelling is complying with BAS readily available through the post-weatherization blower door test. The calculation method for the BAS and the information necessary to convert to CFM_{50} is provided below:

1. The BAS calculation is a 3 step process and requires the following building data:

   a) Living Space Area (in square feet) – This is the occupied square feet of the dwelling. If the basement is finished and/or used as living space, include it in your whole house blower door test (door to basement open) and include the basement in the BAS square feet calculation.

   b) Ceiling height.

   c) Actual number of occupants.

   d) Number of stories above grade.

   e) The Missouri LBL "N" Factor – Missouri is located almost entirely in LBL climate zone 3 and basically is in the middle of the LBL "N" Factor range of 17-20. For the Missouri BAS calculation the "N" Factor to use in the formula, adjusted for building height correction are provided in the following table:

Height-Corrected N-Factors for Missouri		
Number of Stories	**Height Correction Factor**	**N-Factor**
1	**1.00**	**18.5**
1.5	**0.89**	**16.5**
2	**0.81**	**15.0**
2.5	**0.76**	**14.1**
3	**0.72**	**13.3**

2. Step 1: Calculate the ventilation required for the building using the formula below:

   Airflow(b) = 0.35 times house volume divided by 60 = number of cfm

where: volume = (ceiling height) x (living space area)

cfm = cubic feet per minute

3. Step 2: Calculate the ventilation required for the people:

   Airflow(p) = 15 times number of occupants = number of cfm

4. Step 3: Using the higher airflow requirement, convert to CFM_{50}.

   Minimum_ CFM_{50} = Airflow x N

where: N is the LBL conversion factor from the table above.

5. The goal should be to tighten the dwelling to a level equal to the BAS using the cost-effective guidelines described above and not below minimum CFM_{50}. If the dwelling is

tighter than the BAS CFM_{50} before weatherization or if weatherization makes the dwelling tighter than the BAS CFM_{50}, corrective action must be taken that may include the installation of mechanical ventilation or exhausting device.

E. Room-to-Room Pressure Testing

1. Air Handler Pressure Balance Testing for Site-Built Homes

a) This test procedure is performed only in dwellings with air handlers. Room-to-room pressure(s) should be measured in all rooms with forced air heating return or supply ducts and operable doors, after all weatherization installations have been completed. The procedure indicates the magnitude of:

(1) Duct leakage to the outdoors, either through supply or return ducts.

(2) Imbalances of air distribution resulting from closed interior doors. These closed doors can act as dampers to the free flow of air within the conditioned space of the dwelling.

(3) Imbalances of air distribution resulting from airflow differences between the supply side and return side of the ductwork, for example, a restricted return truck.

b) The test procedure is as follows:

(1) Set house up in winter operating mode.

(2) Run a pressure hose from the main body of the house to the outdoors.

(3) Set up a magnehelic gauge zeroed at 15 Pa or a digital pressure gauge in the main body of the house.

(4) Record any pressure difference between the main body of the dwelling and the outdoors. This is the reference background pressure.

(5) A reference background pressure might be due to stack-effect air leakage (especially if it is cold outdoors) or wind.

(6) Turn on the air handler and measure the pressure of the main body of the house with reference to the outdoors.

(7) If the pressure difference between the main body and the outdoors is different with the air handler on than with the air handler off, there is probably some duct leakage to the outdoors.

(a) If the leaks are from the return side of the system, the pressure difference of the dwelling with reference to outdoors will move toward positive when the air handler is activated, or

(b) If the leaks are from the supply side of the system, the pressure difference of the dwelling with reference to outdoors will move toward negative when the air handler is activated.

(8) Close all interior doors.

(9) Repeat the pressure measurement from the main body of the house with reference to the outdoors.

(10) If this pressure is different than it was when all the interior doors were open, the interior doors are acting as dampers to the air distribution system. This can cause thermal discomfort and stuffiness in the room and it can increase the air leakage of the dwelling when the air handler is running.

(11) Take the pressure gauge, being careful to level and zero on 15 Pa when using a magnehelic gauge, and measure the pressure difference across all interior doors. Pressure test and record measurements for all rooms with reference to the main body of the house. Make sure that registers and grilles are not blocked, even though they appear open. Provide pressure relief to any room with readings greater than 3 Pascals by:

(a) Opening the door slightly while measuring the pressure difference across the door. Open the door until the pressure difference is less than 3 Pascals and measure the square inches of opening.

(i) This is the number of square inches to undercut the door, or

(ii) The size of an installed direct grille, offset grilles, or jump duct must be to properly relieve the pressure imbalance caused by the distribution system when the door is closed.

(12) Turn off air handler and return house to the condition it was in before testing began.

F. Duct Leakage Testing

1. General Information

Duct leakage can lead to many problems in a dwelling, the most common one being wasted energy. Other problems can include thermal discomfort, substandard indoor air quality, and combustion venting failure.

Ductwork leakage can take place within the confines of the conditioned envelope of the building or to and from the outdoors. Leakage to or from the outdoors wastes more energy than leakage within the confines of the thermal envelope. Mobile home ducts and site built homes with ductwork in crawl spaces or attics are susceptible to leakage to and from the outdoors.

On the other hand, although duct leakage within the conditioned envelope usually does not have a significant energy impact; it might impose a hazard to occupant health by causing poor indoor air quality or back drafting of combustion appliances. These potential problems are addressed on site by an IAQ appraisal and by performing the worst-case draft test.

Pressure pan and duct blower testing must be done in some dwellings to determine if ducts are leaking to a significant degree to or from the outdoors.

2. Duct Leakage Standards

The following standards shall be followed for mobile homes (including double-wide mobile homes) and site-built homes, including manufactured housing.

a) Mobile Homes

(1) If there is a belly return system in the mobile home, convert it to a conditioned space return system.

(2) For a conditioned space return system, if the sum of the pressure pan readings is 3 Pascal or less:

(a) Visually check furnace-plenum joint and repair and seal with mastic, if necessary, and

(b) Visually check all boots and repair and seal with mastic, if necessary.

(3) For a conditioned space return system, if the sum of the pressure pan readings is between 3 and 5 Pascals:

(a) Visually check all boots and repair and seal with mastic, if necessary.

(b) Visually check any crossover ducts and repair and seal with mastic, if necessary. Make sure these ducts are supported properly.

(c) Visually check furnace-plenum joint and repair and seal with mastic, if necessary, and

(d) Reduce the sum of pressure pan readings to 3 Pascals or less.

(4) For a conditioned space return system, if the sum of the pressure pan readings is greater than 5 Pascals:

(a) Repair and seal as in 3 above, and

(b) Perform duct blower test and implement duct-blower guided duct repair and sealing. Refer to Sections IV and V.

(c) Reduce duct leakage to the outdoors, as measured with a duct blower and blower door, to 10 percent of conditioned floor area.

b) Site-Built Homes, Including Manufactured Housing with ducts located in unconditioned spaces:

(1) If possible, convert the unconditioned space where the ducts are located to a conditioned space, making sure the air and thermal barriers are installed effectively.

(2) Demonstrate the effectiveness of this weatherization work by performing a house-to-zone pressure and flow test (if possible) before and after converting the unconditioned space to a conditioned space.

(3) Always repair disconnected ducts in the space.

(4) The preference is to seal the shell of the space rather than sealing the duct joints.

c) If the unconditioned space is impossible to convert to a conditioned space or it is determined impractical to convert to a conditioned space:

(1) Use a duct blower to determine the duct leakage to the outdoors. Examples of these types of unconditioned spaces include crawlspaces, unconditioned basements, attics, attached or tuck-under garages, and exterior walls.

(2) Repair, seal with mastic, and thermally insulate ducts in unconditioned spaces to at least an R-8.

(3) The goal is to reduce duct leakage to the outdoors, as measured with a duct blower and blower door, to 10 percent of conditioned floor area.

d) For ducts located in conditioned spaces, such as a basement or crawlspace:

(1) Perform a house-to-zone pressure and flow test (if conditions warrant) to determine if the space in question is conditioned in terms of its shell air barrier. The house-to-zone pressure should be 20 Pascals or less.

(2) Visually inspect the conditioned space to ensure that the shell is properly insulated.

(3) If it is determined that weatherization work should be done to the shell of the conditioned space housing the ducts, perform a house-to-zone pressure and flow test (if possible) before and after the work to quantify the effectiveness of the work.

(4) Always repair disconnected ducts in the space.

(5) Sealing the shell of the space rather than sealing the duct joints is preferred.

(6) The goal is for the house-to-zone pressure to be 20 Pascals or less.

3. Pressure Pan Testing Procedures

Pressure pan testing helps find ductwork leaks or disconnections that are connected to outdoor air. Testing before and after duct sealing gives an indication of the effectiveness of sealing efforts. Pressure pans do not read duct leakage directly; they infer leakage to the outdoors by reading the pressure at individual registers. The test procedure involves the following:

a) Install the blower door for a depressurization test. Make sure the dwelling is set up for winter conditions.

b) Open all interior doors, including the door to the basement if the basement is considered conditioned space (heating system, water heater, washer or dryer located there and it is determined that the basement is part of the conditioned envelope).

c) Make sure the furnace burner and air handler is off and will not start during the testing. Remove the furnace filter and ensure that all registers, grilles, and balancing dampers are fully open.

(1) Exception: When performing pressure pan testing in a mobile home, block the filter opening by covering the filter with a plastic bag and reinserting the filter with the bag over it. This blocks the filter opening and results in more accurate pressure pan testing. When the testing is completed, make sure to remove the plastic bag from around the filter.

d) Temporarily seal outside combustion air inlets or ventilation system connections that are directly connected to the duct system. These connections will show up as large leaks if not sealed prior to testing. If supply ducts are located in a garage or other unconditioned space, seal these registers so that the register opening does not show up as a duct leak.

e) Open attics, crawl spaces, garages, and other unconditioned spaces to the outdoor air as much as possible. If the basement is being treated as an unconditioned space, open it to the outdoor air.

f) Only one person at a time should be taking pressure pan readings. Having two registers in different parts of the duct covered by a pressure pan at the same time can affect readings.

g) Depressurize the dwelling to -50 Pascals with the blower door.

h) Make sure the pressure pan is properly connected to the manometer. The proper connection should be reading the space under the pressure pan with reference to the main dwelling pressure.

i) Place the pressure pan completely over each register and grille in conditioned areas.

   (1) If a register or grille is larger than the pressure pan, cover the oversized portion of the register or grille with tape while the reading is recorded.

   (2) If access to a register or grille is difficult, for example at a kitchen counter kick space, cover the entire opening with tape and insert the pressure probe through the tape (near the center of the taped opening) while the reading is recorded.

   (3) When two registers or grilles are closely connected to the same duct run (for example, two registers on opposite sides of the same partition wall), seal one and use the pressure pan on the other unsealed register or grille. Once you have taken the pressure pan reading, remove the seal before proceeding to the next register.

j) Record the pressure pan readings before and after duct sealing activities to get an idea of sealing effectiveness. It will sometimes be useful to record readings during duct sealing. Always start your measurements using the blower door as a reference point and work clockwise around the dwelling.

   (1) If an unconditioned space is not well connected to the outdoors (e.g. unvented crawlspaces or unvented attics) or has very large connections to the house, then the unconditioned space will be at a pressure between the outside and inside house pressure during the blower door test. In this case, the pressure pan reading will show an artificially low number. To correct this misleading number:

      (a) With the dwelling at -50 Pascals, measure the pressure difference between the main dwelling and the unconditioned space in question. (For example, the house to zone pressure is 10 Pascals and the pressure pan reading is 2.0 Pascals).

(b) Multiply the pressure pan reading by the multiplier in Table IV-1 to get the corrected and true reading. (For example, multiply the pressure pan reading of 2.0 Pascals by the multiplier of "5", resulting in a pressure pan reading of 10 Pascals).

Table IV-1

Pressure Pan Multipliers	
House/Zone Pressure	**Pressure Pan Multiplier**
50	**1.0**
45	**1.1**
40	**1.25**
35	**1.42**
30	**1.66**
25	**2.0**
20	**2.5**
15	**3.5**
10	**5.0**
5	**10.0**

k) If you are testing a house with a very leaky building shell and are not able to create a 50 Pa pressure difference with the blower door, perform your pressure pan tests with the house at the highest achievable pressure. In this case you will need to interpret your pressure pan readings carefully. Compare the measured pressure pan reading with the maximum possible reading.

l) Record the pre- and post-weatherization readings on the Zone Pressure Diagnostics Form.

4. Duct Blower Testing for Leakage to Outdoors

This recommended duct blower test requires measurement of duct air leakage to the outdoors, not total duct leakage (to outdoors and indoors).

During this test procedure a blower door fan is used to pressurize the building to the test pressure, while the duct blower system is used to pressurize the duct system to the same pressure as the building. Because the duct system and the inside of the dwelling will be at the same pressure, there will be no leakage between the ducts and the dwelling during the test.

The blower door fan should be set up to blow air into the building for pressurization. Airflow through the blower door does not need to be measured during this test. Because of this, the blower door fan can either be set up in the pressurization test mode, or it can be set up in the standard depressurization test mode, with the fan direction switch reversed to blow air into the dwelling. Refer to your blower door manual for complete instructions.

For residential duct systems, 25 Pascals is generally recommended as the test pressure. This pressure has been adopted by the majority of residential duct testing programs in the U.S. because 25 Pascals represents a typical operating pressure seen in many residential systems.

The test procedures below assume the use of The Energy Conservatory Digital Manometer, Model DG-3, and the Minneapolis Duct Blaster™.

a) Close all exterior doors and windows.

b) Open all interior doors.

c) Open doors to heated or conditioned spaces. Close doors to all unconditioned spaces.

d) Install blower door properly.

e) Shut down solid-fuel appliances before activating blower door or duct blower.

f) Adjust the HVAC system controls so that the air handler fan will not turn on during the duct blower test.

g) Temporarily seal off all supply and return registers, except any central return grille being used to connect the duct blower system to the duct system.

h) Temporarily seal off all combustion air and ventilation air inlets that are directly connected to the duct system.

i) Turn off all exhaust fans, vented dryers, and room air conditioners.

j) Turn off all vented combustion appliances if there is a possibility that the space containing the appliance will be depressurized during the duct blower test.

k) Remove all filters from the duct system and air handler cabinet. If the duct blower will be installed at a central return grille, remove the filter from that grille.

l) If ducts run through unconditioned spaces such as attics, garages or crawlspaces, open vents, access panels, or doors between these spaces and the outdoors to eliminate pressure changes during the test procedure. This should also be done if the duct blower fan will be installed in an unconditioned space, for example, connected to an air handler in a garage or crawlspace.

m) On the blower door, connect the outdoor building pressure tube to the bottom tap on the 60 Pascal magnehelic gauge. The other end of this tubing should either be run to the outdoors, or to the unconditioned zone which contains the majority of the ductwork.

n) Install the duct blower at the furnace or at a large return grille.

o) Decide on the ring configuration for the duct blower.

p) Connect the digital manometer correctly:

   (1) Connect a pressure hose between a register and the input tap on side “A” of the digital pressure gauge. Connect another pressure hose from the reference tap on side “A” to the interior of the dwelling. This means that if you are in the garage, the crawl space, or in the attic, you will need a pressure hose running under a door back to the interior of the house.

(2) Connect a red hose to the top tap on channel “B”. The other end of this hose is connected to the duct blower flow ring.

q) Pressurize the house with the blower door to the test pressure, 25 Pascals. Leave the blower door fan running.

r) Make sure the digital pressure gauge is set on channel “A”.

s) Set up the digital gauge properly.

(1) Turn the mode selection knob to time select and select “1 second”.

(2) Turn the mode selection knob to fan select and select “8”. Choose “8-0” for no duct blower rings, “8-1” for one ring, and so on.

(3) Turn the mode selection to pressure.

t) Turn on the duct blower and pressurize the ducts until the gauge reads zero, that is, the pressure between the duct system and the dwelling is zero. Leave the duct blower running.

u) Re-check the building pressure at the blower door and adjust if necessary.

v) Re-check the duct blower system and adjust if necessary.

w) On the DG-3 digital manometer, connected to the duct blower fan, turn the channel knob to “B” and turn the mode switch to “Flow”. The gauge will now display the air flow through the duct blower fan in cubic feet per minute at 25 Pascals (CFM25). This fan flow is the measured duct leakage to the outdoors at the test pressure of 25 Pascals. This CFM25 flow can also be determined by reading fan pressure from Channel B and converting that pressure reading to flow by using the Duct Blaster™ Flow Conversion Table in the Duct Blaster™ instruction manual.

x) Check to make sure you have set the DG-3 correctly.

y) It is a good idea to move the register pressure hose to other registers. If the dwelling-to-duct pressure does not remain close to zero, there are probably significant duct leaks. Inspect and repair any obvious duct disconnects before continuing.

z) When the duct sealing and duct blower testing are completed, shut down and remove the blower door and duct blower.

aa) The final worst-case draft test should be performed after the duct testing and duct sealing is completed.

G. Pressure Testing Air Barriers

1. General Information

Leaks in air barriers cause energy and moisture problems in many homes. You can test air barriers for leakiness during blower-door testing. Air-barrier leak testing avoids unnecessary visual inspection and air-sealing in hard-to-reach areas. Air-barrier pressure testing uses a manometer to measure pressure differences between zones in order to estimate air leakage between zones.

Specifically air-barrier leak-testing can:

a) Evaluate the air tightness of portions of a building's air barrier, especially floors and ceilings.

b) Decide which of two possible air barriers to air seal, for example, the floor versus foundation walls.

c) Estimate the approximate leakage area (ALA) of air leaks through a particular air barrier, for the purpose of estimating the materials and labor necessary to seal the leaks.

d) Determine whether building cavities like floor cavities, porch roofs, and overhangs are conduits for air leakage.

e) Determine whether building cavities, intermediate zones, and ducts are connected by air leaks.

Air-barrier leak-testing provides a range of information from simple clues about which parts of a building are leakiest to specific estimates of the airflow and hole size through a particular air barrier like a ceiling.

2. Primary Versus Secondary Air Barriers

Intermediate zones are unconditioned spaces, sheltered within the exterior shell of the house. Intermediate zones include: unheated basements, crawl spaces, attics, enclosed porches, and attached garages. Intermediate zones can be included inside the home's primary air barrier or outside it. Intermediate zones have two potential air barriers: one between the zone and house and one between the zone and outdoors. For example, an attic or roof space has two air barriers: the ceiling and roof.

The primary air barrier should be adjacent to the insulation to ensure the insulation's effectiveness, so testing is important to verify that insulation and primary air barrier are together. The most airtight of these two air barriers is the primary air barrier and the least airtight is the secondary air barrier. Sometimes we're surprised during testing to find that our assumed primary air barrier is actually secondary, and the secondary air barrier is actually

primary. The air barrier should be a material that is continuous, sealed at seams, and is itself relatively impermeable to airflow.

You can find valuable information about the relative leakiness of rooms or sections of the home with closable interior doors during a blower-door test. Listed below are 5 simple methods:

a) Feeling zone air leakage: Close an interior door partially so that there is a one-inch gap between the door and door jamb. Feel the airflow along the length of that crack, and compare that airflow intensity with airflow from other rooms, using the same technique. Discovering that there is a lot of leakage coming from one zone and only a little coming from another is this test's limitation.

b) Difference in CFM_{50}: Check the difference in CFM_{50} when an interior door is closed versus when it is open. You will probably have to adjust the blower door after opening or closing the interior door to restore 50 Pascals house pressure. This technique works well for basements, attached garages, hallways in multi-family buildings, crawl spaces with interior access hatches, and other zones that may contain significant air leaks.

c) Zone pressure difference: Check the pressure difference between a closed room or zone and the main body of a home. Larger pressures indicate larger potential air leakage within the closed room or zone or a tight air barrier between the zone and main body.

d) Observing the ceiling/attic floor: Pressurize the home to 50 Pascals and observe the top-floor ceiling from the attic with a good flashlight. Air leaks will show in movement of loose fill insulation, blowing dust, moving cobwebs, etc.

e) Observing smoke movement: Pressurize the home to 50 Pascals and observe the movement of smoke through the house and out of its air leaks.

All of these tests are very approximate. Feeling airflow with your hand is crude and inaccurate, but this simple technique has pointed out many air leaks that may have remained hidden without it. Air leakage, restricted by closing a door, may have almost equal alternative paths, rendering tests b and c inaccurate. However, closing doors to leakier rooms will usually produce a greater reduction in CFM50 than closing doors to tighter ones. Leakier rooms will usually have greater pressure differences with the main zone than tighter rooms. Only practice and experience can guide your decisions about the applicability and usefulness of these tests.

3. Using Manometers to Test Air Barriers

The digital manometer or analog manometer, used for blower door testing, can also measure pressures between intermediate zones, indoors, and outdoors during blower-door tests.

When the blower door depressurizes the house to –50 Pascals, the home's intermediate zones will also be depressurized to between 0 and –50 Pascals. The amount of depressurization depends on relative leakiness of the zone's two air barriers. For example, in an attic with a very well ventilated roof and a fairly airtight ceiling, the attic won't be depressurized much by a blower-door test. The leakier the ceiling and the tighter the roof, the more an attic will be depressurized. This holds true for other intermediate zones like crawl spaces, attached garages, and basements.

4. Simple Attic Leak Testing

a) Air-sealing crews commonly use simple diagnostic techniques like the attic-pressure procedure described below. This procedure assumes that the roof is well-vented. There are many variations of this test used to evaluate other air barriers in other intermediate zones.

   (1) Depressurize house to –50 Pascals with a blower door.

   (2) Find an existing hole or drill a hole through the ceiling between the conditioned space indoors and the attic.

   (3) Connect the input port (digital manometer) or the high-pressure port (analog manometer) to a hose connected into the attic.

   (4) Leave the reference port (digital manometer) or the low-pressure port (analog manometer) open to the indoors.

   (5) Read the negative pressure given by the manometer. This is the house-to attic pressure, which will be -50 Pascals if the ceiling is airtight and the roof well-vented.

   (6) If the reading is significantly different from -50 Pascals, find the air barrier's largest leaks and seal them.

   (7) Repeat steps 1 through 5, performing more air-sealing as necessary, until the pressure is as close to -50 Pascals as possible.

b) The house-to-attic pressure will be -50 Pascals if the ceiling is airtight or if the roof has a large area of roof vents or if the ceiling's air leakage is insignificant compared to vents and air leaks in the roof.

   (1) Readings of 25-to-50 Pascals house-to-attic pressure mean that the ceiling is tighter than the roof.

   (2) Readings of 0-to-25 Pascals house-to-attic pressure mean that the roof is tighter than the ceiling.

(3) Readings around 25 Pascals house-to-attic pressure indicate that the roof and ceiling are equally airtight or leaky.

5. Testing Intermediate Zones and Building Cavities

Use the following test procedures for measuring zone pressures in attics, crawl spaces, building cavities, and attached or tuck under garages.

a) Set-up blower door for house air-leakage test.

b) Ensure that the hose to the outside will not be affected by the blower door airflow.

c) Close any openings (door, access hatch) between the intermediate zone and conditioned space, taking care not to pinch hose if it goes through the door or hatchway.

d) Depressurize house to -50 Pascals. If the house cannot be depressurized to -50 Pa, depressurize to highest multiple of 5 and use blower door conversion table.

e) Connect hose from zone to input tap on manometer. Connect hose from the outside to reference tap.

f) Record pressure of zone with reference to the outside.

6. Interpreting Zone Pressure

Pressure readings between the zone and outside indicate whether the air barrier is aligned with the insulation. In all cases, both the air barrier and insulation should be in the same building section. Pressure readings also give clues about the amount of air-sealing work required.

Zone-to-outside readings of 0 to -25 Pascals indicate that the air barrier between the living space and zone is tighter than the barrier between the zone and outside (for example, the ceiling is tighter than the roof in an unfinished attic, shown here). This is good in that the primary air barrier is adjacent to the insulation. However, the air barrier (ceiling) can be made tighter if the pressure reading is more negative than -5 Pascals. Pressure readings more negative than -5 Pascals indicate that bypasses are present in the ceiling. Bypasses should be located and sealed.

Zone-to-outside readings of -25 Pascals to -50 Pascals indicate that the air barrier between the zone and outside is tighter than the air barrier between the living space and zone. For example, the crawl-space foundation walls are tighter than the floor between crawl space and conditioned area, as shown here. If the crawl space foundation walls are the thermal boundary, holes in the foundation wall should be sealed until the pressure difference between the crawl space and outside is more negative as high as you can get them.

If the floor above the crawl space is the thermal boundary, the air barrier (foundation walls) and the insulation (floor above the crawl space) are misaligned. A decision of where to locate the thermal boundary must be made, followed by appropriate air-sealing and insulation work.

Zone-to-outside readings around -25 Pascals indicate that the air barrier between the zone and conditioned space and the air barrier between the zone and outside are equally leaky. If there is currently no insulation, decide where the thermal boundary should be and perform appropriate air-sealing and insulation work accordingly.

Generally, the thermal boundary (air barrier and insulation) should be between the conditioned space and attic. The thermal boundary can be either the foundation walls or floor above crawl space. The thermal boundary should always be between the conditioned space and tuck-under or attached garage, to separate the living spaces from this unconditioned and often polluted zone.

Building cavities like wall cavities, floor cavities between stories, and soffits in kitchens and bathrooms can also be tested as described above to determine their connection to the outdoors.

H. Advanced Zone Pressure Diagnostics (ZPD) Testing

1. General Information

Use the Zone Pressure Diagnostics Calculation Utility (ZPDCU) software package for these tests unless instructed otherwise. The ZPD software and user guide are downloadable from The Energy Conservatory Web: http://www.energyconservatory.com/products/products8.htm. Follow the procedures in the user guide to complete the ZPD diagnostics.

IV. General Heat Waste & Air Sealing Measures

A. General Heat Waste

There are materials that are typically cost-effective when applied to most dwellings and are generally know as General Heat Waste measures. In order to be the most cost-effective, these treatments require the material to be properly applied in appropriate locations so the application will produce fuel savings. General heat waste materials include water heater insulation, water heater temperature adjustment, pipe insulation on the first six feet of hot water pipes leading from a water heater and low-flow showerheads.

1. Water Heaters

a) All water heaters must have a pressure and temperature relief valve and a safety discharge pipe. Install a relief valve and discharge pipe if none exists. The pipe must terminate 6 inches above the floor and be made of rigid metallic material or high temperature plastic.

b) Water heaters should be re-insulated to at least R-10 unless the water heater label gives specific instructions not to insulate or water heater is already insulated.

c) Water heater insulation must not obstruct draft diverter, pressure relief valve, thermostats, hi limit switch, plumbing pipes, or access plates.

d) Adjust water temperature to a maximum of 120°F with clients' approval, unless the client has a older automatic dishwasher without its own water heating booster. In this case the maximum setting is 140°F.

2. Gas-Fired Water-Heater Insulation

a) Keep insulation at least 2 inches away from the access door to the burner.

b) Insulation should be cut away from the water heater's gas valve and drain valve to provide ample clearance for access.

c) Do not insulate the tops of gas fired water heaters.

3. Electric Water-Heater Insulation

a) Set both upper and lower thermostat to keep water at 120°F before insulating water heater.

b) Insulation may cover the water heater's top if the insulation will not obstruct the pressure relief valve.

c) Access holes should be cut in the insulation for the heating element thermostats, or better, thermostat location should be marked with a permanent marker to preserve the insulation's integrity until the access is needed.

4. Water Heater Blankets

a) The installation of water heater blankets on electric water heaters in conditioned spaces is recommended unless this will void the warranty. Gas water heaters located in conditioned space should not be insulated.

b) Water heaters located in unintentionally heated areas should be insulated with the following materials:

(1) Fiberglass batt insulation with a protective covering is the preferred material for the water heater blanket, however other appropriate materials may be used if designed for such purpose or approved by the LIWAP Program Administrator.

(2) At least an R-10 water heater blanket is preferred on all tanks not labeled with a prohibition to installing additional insulation to that already installed by the manufacturer.

(3) A water heater blanket must be secured to the water heater with at least two (2) straps. The installed straps must be securely connected not excessively compress the water heater blanket.

c) Installation

(1) The water heater tank must be inspected to determine the type of water heater (gas, electric, other), and whenever possible, the amount of existing insulation.

(2) If there are signs that the water heater is leaking, this problem must be solved before insulation is added.

(3) Water heaters outside the living space, including mobile home water heaters in exterior closets, must be insulated if the total existing tank insulation is less than R-11.

5. Pipe Insulation

a) Insulate the first 6 feet of hot water pipes.

b) Cover elbows, unions and other fittings to same thickness as pipe.

c) Keep pipe insulation at least 3 inches away from flue pipe.

d) Interior diameter of pipe sleeve must match exterior diameter of pipe.

6. Energy-Saving Showerheads

a) An energy-saving (low-flow) showerhead may be installed with client permission, if the existing showerhead flow is measured at greater than 3 gallons per minute (gpm) and the installation does not require the use of a plumber.

b) The energy-saving showerhead must have a flow rating of 2.5 gpm or less.

c) If an energy-saving showerhead is installed in conjunction with lowering the domestic hot water temperature, the chances are high that the client will not notice less hot water for showering, as they might if the temperature is reduced without installing the new showerhead.

B. Air Sealing Requirements

Refer to Section IV – Shell and Duct Air Leakage Diagnostics for guidance on cost-effective air sealing.

Before air leakage reduction measures are installed, the building envelope must be defined and existing health and safety problems must be corrected.

Infrared scanning should be used as a tool to identify areas of excessive air leakage. The infrared scanning device is a powerful tool for finding air leaks when used in conjunction with a blower door. Subgrantees are advised to use infrared scanning whenever the equipment is available and the use is practical.

1. Air Sealing Guidelines

a) The approach to air sealing should be to seal high (attic) spaces first, low (crawl or basement) spaces second and the middle spaces around windows, doors and other penetrations last as determined cost-effective or to improve client's comfort.

b) Before blown insulation is installed, all obvious leaks should be sealed. These leaks might include, but are not limited to:

(1) Open top plates (usually in balloon-frame dwellings).

(2) Chases around masonry and metal chimneys.

(3) Chases around plumbing stacks.

(4) Missing window sashes or lights.

(5) Installation of sash locks on double- and single-hung windows. Two cam-type locks per window sash are preferred.

(6) Doors that are misaligned in their frames.

(7) Missing drywall or other interior finish materials.

(8) Missing or misaligned attic doors or hatches.

(9) Missing or misaligned outside access doors in basements.

(10) Other obvious holes or leaks in the dwelling envelope that:

(a) Are cost-effective to seal,

(b) Prevent the structure from damage, or

(c) Are necessary for the proper installation of insulation.

c) Whenever feasible and more cost-effective, the installation of tube-filled, high density cellulose insulation in sidewalls, cathedral ceilings, convective bypass areas, open top plates/drop ceilings and other air leakage locations is preferred over the use of air sealing techniques using air barrier materials for achieving reductions in air leakage.

d) Documentation of materials, labor, and CFM50 reductions must be retained in the client file.

2. Penetrations and Holes

a) All penetrations through the exterior sidewalls of a unit that are sealed must be sealed from the interior with the exception of:

(1) Foundations, which may be sealed from either interior or exterior.

(2) Any hole or penetration requiring sealing to keep out rain or snow.

b) Openings in recessed light fixtures must not be sealed unless the fixture is rated as an "IC" fixture.

c) A fire-rated material, such as galvanized tin or aluminum, must be used to seal gaps around heat sources such as masonry or metal chimneys. This fire-rated material must be sealed with high temperature caulking to the chimney and to surrounding framing and finish materials.

(1) Unfaced fiberglass insulation of at least 3 ½ inches in thickness must be used to wrap the chimney above this fire-rated material. This fiberglass serves as a fire shield for cellulose installed against the fiberglass.

(2) If an existing chimney or flue is treated incorrectly, correct it to comply with these standards. If it is not reasonable to bring a chimney up to these standards, document this fact in the client file and include photographs.

3. Fireplace Plugs, and Equipment Covers

a) Removable fireplace "plugs" should be installed in a manner that prohibits the use of the fireplace unless the "plug" is removed.

b) Covers for evaporative coolers, whole house fans, and window air conditioners should be easy to remove and reinstall.

C. Ducted Distribution Requirements

1. Ductwork Inspection, Cleaning, and Sealing

a) Ductwork must be tested and sealed according to Section III – Shell and Duct Leakage Diagnostics.

b) Delivery and return ductwork must be cleaned as necessary to remove large objects and debris, which may impede airflow through the heating system.

c) Uncover any blocked registers or grilles. Explain to the client the importance of maintaining the unrestricted airflow.

d) As necessary, delivery and return air grilles and registers must be removed and cleaned to remove excessive dirt and debris, which may impede airflow.

e) When appropriate, remove ducts, registers, and grilles located in unconditioned spaces.

f) Ductwork outside the thermal envelope of the dwelling must be connected and sealed.

g) All accessible return air ductwork within a combustion appliance zone (CAZ), except gravity systems, must be sealed enough to eliminate the potential for back drafting.

h) Ducts and registers into non-living areas of the structure may be sealed off with owner permission.

i) Existing crawl-space plenums should be abandoned and replaced with a sealed duct system.

j) Ductwork sealing shall be done with mastic, mesh tape, sheet metal, or pressure sensitive metal tape.

(1) Gaps of 1/8 inch or less may be sealed with:

(a) Duct mastic.

(b) Pressure sensitive metal tape

(2) Gaps between 1/8 inch and 1 inch shall be sealed with:

(a) Duct mastic embedded with fiberglass mesh.

(3) Gaps larger than 1 inch shall be covered with sheet metal or valley flashing, fastened with screws, and sealed with mastic.

k) If the boot is loose to the floor it shall be reattached to the sub floor with roofing nails or staples. Wood screws may also be used. Ensure that the heads of the screws do not prevent the register or grille from fitting into the boot.

(1) If gaps exist between the boot and the floor and the space below the floor is unconditioned, fill the gaps with mastic or other appropriate materials.

2. Ductwork Sealing Materials

a) Cloth duct tape shall never be used for duct sealing.

b) Existing duct tape must be removed before installing duct mastic or other approved sealing materials

c) Mastic shall meet the following requirements:

(1) Non-toxic and water resistant.

(2) UL listed and labeled per UL 181A or 181B standards.

(3) Shall be compatible with the duct material to which it is applied.

d) Mesh fabric used to reinforce duct mastic shall meet the following requirements:

(1) Comply with the mastic manufacturer's specifications.

(2) Made of fiberglass.

(3) Have at least a 9 x 9 weave per inch.

(4) Be at least 0.006 inches in thickness.

e) Pressure sensitive metal tape shall meet the following requirements:

(1) UL listed and labeled per UL 181A or 181B standards.

(2) Tape width must be at least 2 inches.

(3) Butyl adhesive must be at least 15 mils thick.

f) Draw bands used to support or seal ductwork shall meet the following requirements:

(1) Comply with the manufacturer's installation instructions.

(2) Weather- and UV-resistant duct ties or stainless steel worm drive clamps.

(3) Loop tensile strength must be at least 150 pounds.

(4) Service temperature rating must be at least 165oF.

g) Duct supports shall conform to the duct manufacturer's installation instructions and must be corrosion resistant.

V. Insulation Requirements

A. Attic Insulation

1. General Procedures

a) Before installing insulation, a thorough inspection of the attic area should be performed.

b) The inspection should include the determination of the R-value and integrity of existing insulation, location of air leakage passage from the conditioned spaces to the attic, and the suitability of the structure for receiving insulation. Refer to Table VI-1, developed by the Building Performance Institute, for guidance in the evaluation of insulation.

Table VI-1 -- Effective R-values of Batt Insulation

	"Good"	"Fair"	"Poor"
Measured Batt Thickness (inches)	Effective R-value (2.5 per inch)	Effective R-value (1.8 per inch	Effective R-value (0.7 per inch)
0	0	0	0
1	3	2	1
2	5	4	1.5
3	8	5	2
4	10	7	3
5	13	9	3.5
6	15	11	4
7	18	13	5
8	20	14	5.5
9	23	16	6
10	25	18	7
11	28	20	8
12	30	22	8.5

1. Measure the insulation thickness.

2. Determine the condition of the installation using the following criteria:

✓ *Good – No gaps or other imperfections*

✓ *Fair – Gaps over 2.5% of the insulated area. (This equals 3/8 inch spacing along a 14.5 inch batt.*

✓ *Poor – Gaps over 5% of the insulated area. this equals ¾ inch space along a 14.5 inch batt.*

3. Look up the effective R-value of the installed insulation using the condition and measured inches.

c) The inspection should determine any repair work associated with the installation of the attic insulation. Repairs should be completed before installing insulation.

2. Moisture Inspection and Repair

a) Roof leaks and all other attic moisture problems shall be repaired prior to the installation of attic insulation.

b) All vents from combustion appliances must be vented through the roof or sidewall.

c) Exhaust vents may be vented through the roof to provide a remedy to an identified moisture problem.

d) Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.

3. Electrical Safeguards

a) Correct electrical problems such as unsafe wiring, uncovered junction boxes, or electrical situations which must be corrected prior to performing any other work in the attic(s). If insulation exists, ensure that wiring is safe and meets applicable codes.

b) All visible electrical junctions must be flagged and be installed in covered junction boxes if additional insulation is installed.

c) Lighting fixtures, excluding IC (insulation contact) rated recessed lights and associated junction boxes, shall be blocked with rigid material, to ensure a minimum insulation clearance of 3 inches and a maximum clearance of 6 inches.

d) Knob-and-tube wiring:

(1) If knob-and tube wiring is active in an attic, any insulation must be kept at least three inches from the wiring. Blown insulation must be appropriately dammed to keep the insulation from advancing closer than three inches from the knob-and-tube wiring.

(2) If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, the attic may be insulated without special precaution.

4. Treatment of Other Hazards

a) Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personal safety during work.

b) Repair any rotted, broken, or damaged attic structural components. Ensure that the ceiling will safely hold the weight of the insulation. Repair or replace any weakened, damaged, or missing interior ceiling surface.

5. Attic Access

a) When it is necessary to install an interior access in the ceiling, it must be at least 20 inches by 30 inches, and shall be weather-stripped and insulated to the same level as the attic floor or to at least R-19.

b) A ceiling access shall have an insulation dam, made of rigid materials, that exceeds the height of the insulation to be installed. The dam must be strong enough to hold the weight of a person entering or exiting the attic.

c) If there are no interior accesses, at least one exterior access to each attic space shall be left for inspection purposes.

d) When it is necessary to install an interior access in a knee wall, it must be at least the knee wall stud cavity width x 24", and shall be weather-stripped and insulated to the same R-value as the knee wall. A latch shall also be installed to ensure air tightness.

6. Insulation Shielding and Blocking

a) All electrical fixtures, excluding IC (insulation contact) rated recessed lights and covered junction boxes, shall be blocked with rigid material, to ensure a minimum insulation clearance of 3 inches and a maximum clearance of 6 inches.

b) No insulation, including fire-rated insulation shall be installed above recessed light fixtures, except IC (insulation contact) type, so as to entrap heat or prevent free air circulation.

c) Insulation barriers of fire-rated material shall be used around heat-producing sources. Barriers shall be slightly higher than the finished height of the insulation. If metal is used as an insulation barrier, a 3-inch clearance must be maintained between the metal insulation barrier and the heat-producing source and no insulation shall be left within the blocked area. Blocking must be installed so that it is effective in shielding the heat source from the insulation.

d) Metal blocking must be notched so that it does not contact electrical wiring.

e) If insulation is added to the attic, rigid permanent blocking is required around the attic access openings if they open into a living area and adequate clearance exists.

f) A fire-rated material, such as at least 26 gauge galvanized tin, must be used to seal gaps around heat sources such as masonry or metal chimneys. This fire-rated material must be sealed with high temperature caulking to the chimney and to surrounding framing and finish materials.

(1) Unfaced fiberglass insulation with an ASTM rating as a non-combustible material of at least 3 ½ inches in thickness, may be used to wrap the chimney above

this fire-rated material. This fiberglass serves as a fire shield for cellulose installed against the fiberglass.

(2) If an existing chimney or flue is treated incorrectly, correct it to comply with these standards. If it is not reasonable to bring a chimney up to these standards, document this fact in the client file and include photographs.

g) Requirements for furnaces installed in attics:

(1) Attic furnace blocking must be installed to ensure a minimum free air clearance of 18 inches, but not more than 24 inches.

(2) If a working platform is present for an attic furnace, or if one is installed by the subgrantee, 30 inches of clearance adjacent to the furnace controls must be provided.

(3) Attic furnaces must be checked after adding attic insulation to ensure they are free of insulation and operate properly.

B. Installation Methods for Attic Insulation

1. General Procedures

a) Locate and seal attic thermal bypasses, chases, and open-topped partition walls. Properly treat ceiling height changes and stairwells as necessary to stop leakage. Seal knee wall floor cavities. Check for completion of bypass sealing before installing any insulation.

b) Attic insulation must be installed in such a manner that ensures complete coverage over heated areas, and is installed at an even depth except where physical constraints may exist.

c) Insulation must be installed according to the manufacturer's specifications for coverage and R-Value. Calculating the number of bags to be installed per the manufacturer's specifications is the best method for meeting manufacturer's specifications for loose fill insulation.

d) Attics should be tested using zonal pressure diagnostics when the housing construction type or the air leakage rate indicates that there may be hidden air leakage or bypass pathways into the attic. This test should be used to determine quality and completeness of air leakage and bypass sealing, prior to, and then after, installing insulation.

e) Cellulose insulation is the preferred choice for installation in site built homes and should be used unless technical issues warrant other product consideration.

2. Insulation Coverage and Density

a) Insulate uninsulated open-joist attics and other areas that form the thermal barrier to the level recommended by the NEAT audit program.

b) At the beginning of each job, measure the density of the insulation for a selected test area before beginning the major installation. This should be done for insulation blowing jobs using any nozzle type or tubing method. The density of blow insulation must be within the range of the values listed below.

c) Insulate enclosed areas (under floors, slopes, under knee wall cavities, etc.) to high density level as follows:

(1) Blown cellulose 3.25 to 3.75 lb/ft3

(2) Blown fiberglass 1.6 lb/ft3

d) Insulate knee wall areas as follows:

(1) Blown cellulose 3.25 to 3.75 lb/ft3

(2) Blown fiberglass 1.6 lb/ft3

(3) Fiberglass batts R-19

e) Densely packing cellulose insulation is preferred as a method for sealing air leakage paths and bypass leakage in attics, where feasible.

f) Calculating the number of bags is the preferred method for determining the proper amount of material to be installed into an attic area at a given R-value.

g) Where the combined material and labor costs can be reduced, it is preferred that dropped soffits and similar construction details be filled with cellulose insulation.

h) When a vapor barrier is installed with the insulation, the barrier should be installed on the warm side of the insulation and never more than 1/3 of the R-value away from the warm-side surface.

i) Add necessary insulation to eliminate voids and areas of incomplete coverage. Cut or pull back existing fiberglass batts two feet from the soffit and blow and dense pack the perimeter. Prepare floored areas or other restricted zones with existing insulation for high-density application.

3. Enclosed Ceiling Cavities

a) When insulating enclosed ceiling cavities, it is preferred that insulation be installed from a location other than through roofing material. Such locations may include rafter cavities that open into an attic area, through the eve, or from the interior of the home.

4. Storage Space

a) Where attic space is being used for storage, subgrantees should request the client remove storage items from the area.

b) In cases where the client is physically unable to perform this task, subgrantees should include the removal of items in the cost-effective analysis of installing insulation, and proceed with the measure if it is cost-effective (savings-to-investment ratio of 1.00 or greater).

5. Attic Access Insulation

a) If attic insulation is added, access doors over living areas must be insulated as close as possible to the same R-value as the attic or at least R-19.

6. Ductwork Insulation

a) Install a minimum of R-8 (preferably R-11 or greater, when possible) on ducts and plenums. It is preferred that attic ducts be draped with an unfaced blanket insulation and blown over with loose fill insulation, to at least the depth of the surrounding insulation. If faced duct insulation is installed, it is preferred that the facing be to the outside.

b) Ductwork must be sealed appropriately with the proper materials (duct mastic) before insulation is installed.

c) A minimum of 6 inches clearance between duct insulation and heat sources must be maintained, unless the material is rated for closer proximity.

7. Drill-and-Blow Patching

a) If a drill-and-blow method is used for installing ceiling insulation, holes must be properly plugged, secured with adhesives, and sealed.

C. Attic Ventilation

1. General Installation

a) Ensure that existing vents are not blocked, crushed or otherwise obstructed. Correct problems as necessary, or replace.

b) When attic insulation is installed, a reasonable amount of attic ventilation should be in place, unless local codes supersede.

c) When roof vents are installed they should be nailed and well sealed to the roof to prevent water leakage.

d) All ventilation openings should have suitable louvers and screens to prevent snow, rain and insects from entering the attic.

2. High-Low Vents

a) Roof vents should be installed close to the peak.

b) Install high gable vents at least 3 feet above the soffit or gable vent used for low venting.

3. Gable Vents

a) Gable-end vents should be installed as high in the gable as possible and positioned to provide cross ventilation.

b) Steps shall be taken to prevent wind washing of insulation around the attic vents.

4. Knee Wall Ventilation

a) Knee wall attics or attic spaces that are sealed from other attic spaces may need to be ventilated as if they are a separate attic.

5. Attic Vent Area Guideline

a) When attic ventilation is installed, the following guideline is allowed:

(1) If air-sealing work has been completed at the attic floor then one square foot of net-free ventilation may be installed for every 300 square feet of attic floor area.

D. Sidewall Insulation

1. General Procedures

a) An inspection from the interior and exterior of the home should be performed prior to installing insulation. This inspection should identify all potential hazards and needed repairs.

b) An inspection from the exterior of the home should include an examination of the following:

(1) Building construction details.

(2) Siding type and condition.

(3) The location of electrical, gas, oil and phone lines.

(4) Plumbing pipes.

(5) Existing moisture and drainage problems.

(6) Existing structural problems.

c) An inspection from the interior of the home should include an examination of the following:

(1) Interior wall siding type and condition.

(2) Electrical and plumbing utilities.

(3) Duct work in wall cavities.

(4) Dropped or suspended ceilings.

(5) Moisture problems.

d) An inspection from the attic should include an examination of the following:

(1) Open top plates and balloon framing.

(2) Type of electrical wiring in the walls.

(3) Knee wall areas.

e) Correct electrical problems such as unsafe wiring, uncovered junction boxes, or electrical situations which must be corrected prior to performing any insulation work. If insulation exists, ensure that wiring is safe and meets applicable codes.

f) Knob-and-tube wiring:

(1) If active knob-and-tube wiring is found in a dwelling attic, walls, or basement, the walls of the dwelling must not be insulated.

(2) If knob-and-tube wiring has been deactivated and the dwelling has been rewired with BX, Romex, or other approved electrical cable, the walls may be insulated without special precaution.

2. Moisture Inspection and Repair

a) Any leaks or other moisture problems must be repaired prior to the installation of wall insulation.

b) Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.

3. Treatment of Other Hazards

a) Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personal safety during work.

b) Remove any items that need to be moved in order to install wall insulation effectively.

c) Repair any rotted, broken, or damaged structural components. Ensure that the finished wall material will safely withstand the pressure of the insulation. Repair or replace any weakened, damaged, or missing interior wall surface.

d) Set up ladders in a safe manner, using ladder levelers or other safety devices, to compensate for yard inclines or other physical obstructions to safe ladder use.

4. Interior Inspection and Repairs

a) Repair or replace weak or damaged drywall or lath and plaster sections. Locate any interior areas of paneling with no sub-wall surface, or that are not securely fastened. Determine an insulation strategy which will not damage the paneling. Repair or replace damaged or missing baseboard, casing, jambs, etc., that may allow insulation to escape from the wall cavity. Holes drilled for insulation must be finished and returned to a condition as close to the original as possible.

b) Locate the positions of all wall-mounted switches and outlets before beginning insulation work. Locate all chases, utility runs, duct runs, wall heaters, vent fan

penetrations, etc. prior to insulating. Block around these areas, if possible. If it is not possible to block around an area, avoid that area when insulating.

c) Find any interior soffit areas, pocket doors, or other structural details which may need preparation prior to insulating, and prepare as necessary. Locate critical framing junctures and ensure adequate insulation density.

5. Exterior Inspection and Repairs

a) Note all types of siding material. Note siding material which may contain asbestos. Wherever possible, determine the presence and condition of previous layers of siding or sub-siding. Determine the best drilling strategy (the tubing method or the nozzle method). As the primary acceptable method, the siding must be lifted or temporarily removed to gain access for drilling. Permission is needed from the client to drill through any type of exterior siding.

b) Repair or replace severely deteriorated window or door components as directed by the work order. Replace all missing glass.

c) Patch holes in exterior walls.

d) Determine the source and correct any problem which has led to moisture in wall cavities prior to installing insulation. Repair or replace damaged, rotted, or deteriorated siding to ensure the integrity of the insulation. If any missing siding, flashing, etc. would allow disintegration of installed insulation, replace it with a compatible material.

e) Access structural additions and critical junctures to determine the ability of these areas to contain high-density insulation. Correct any openings or gaps prior to installing insulation.

E. Installation Methods for Wall Insulation

1. General Procedures

a) Wall areas above windows and doors (except in mobile homes), and the area below windows must be insulated, whenever possible.

b) Uninsulated exterior walls without drywall, paneling or other interior finishing material, must be insulated if adding interior finishing material and insulation is deemed cost-effective.

c) Fiberglass insulation must not be left exposed in living areas.

d) The tube-fill method is recommended when technically possible rather than the nozzle method.

e) Removal of siding before drilling the sheathing is considered “best practice” and should be the method used unless conditions make this impossible or an unacceptable risk.

f) The tubing method may be used to install insulation into sidewall by drilling one hole per story. A flexible tube is inserted in the hole, the end being pushed to the area to be insulated. As the insulation fills the area, the tube is slowing pulled out of the drilled hole, filling the entire cavity as the tube is retracted.

2. Blocking

a) Construction details that allow insulation to escape from sidewall cavities such as balloon framed walls must be blocked or packed with insulation or other material in a manner that effectively retains the insulation material.

3. Materials

a) In site-built dwellings:

(1) Insulate all closed-cavity sidewalls to 3.25 – 3.75 lbs/ft3 with cellulose insulation unless this is not possible. If it is not possible, documentation for the reason must be included in the client file.

(2) Insulate open cavity walls with fiberglass, faced or unfaced, using a density and thickness appropriate for the cavity. Cover any flammable insulation facing or vapor barrier installed in a living space with a fifteen-minute fire rated material such as ½ inch drywall (taped once) or ¾ inch plywood.

(a) A fifteen-minute fired rated covering is not required in an unconditioned or conditioned space that is also a living space.

(3) Rigid plastic insulation may be used when appropriate. Cover any rigid insulation or vapor barrier installed in a living space with a fifteen-minute fire rated material such as ½ inch drywall (taped once) or ¾ inch plywood.

(a) A fifteen-minute fired rated covering is not required in an unconditioned or conditioned space that is also a living space.

b) For mobile home wall insulation materials, refer to Section VI.

4. Insulation Coverage, Density, and Voids

a) Sidewall insulation must be installed according to manufacturers' recommended density, and in such a manner that does not allow settling of the material to occur.

b) Determine the appropriate sidewall insulation technique(s) to be used. Insulate all sidewalls to 3.25 – 3.75 lbs/ft3 with cellulose insulation, unless a technical barrier prevents this technique.

c) When using blown fiberglass, install at a density of 1.6 lb/ft3.

d) Subgrantees should obtain a warranty, of at least one-year, against voids of more than 5 percent from subcontractors installing wall insulation.

5. Plugs and Patching

a) Where possible, exterior lap siding must be removed and sheathing be drilled for the installation of insulation. If the exterior siding is properly shedding water, then patching of holes in the sub-siding is not required. Small pieces of fiberglass insulation can be inserted into the hole to prevent wicking of moisture from outside.

b) Plugs that are compatible with the siding or wall type must be used to cover the exposed surface that has been drilled.

c) Plugs must be sealed tightly and glued. They must be primed when exposed to weather.

d) Subgrantees or their contractors should paint and may texture to match plugs to the surrounding wall, but may not paint or texture the entire wall.

6. Brick Siding

a) Interior drill and blow techniques are preferred for homes with brick veneer siding that are going to receive sidewall insulation.

7. Quality Control

a) When possible infrared scanning should be used as a quality control tool to check wall insulation work and identify areas of excessive air leakage. The infrared scanning device is a powerful tool for finding air leaks when used in conjunction with a blower door. Subgrantees are advised to use infrared scanning whenever the equipment is available and the use is practical.

F. Foundation Insulation

This section addresses rim joist insulation, basement wall insulation, and crawlspace wall insulation.

1. General Procedures

a) An inspection from the interior and exterior of the home should be performed prior to installing insulation. This inspection should identify all potential hazards and needed repairs.

b) An inspection from the exterior of the home should include an examination of the following:

(1) Building construction details.

(2) Foundation type and condition.

(3) The location of electrical, gas, oil and phone lines.

(4) Plumbing pipes.

(5) Existing moisture and drainage problems.

(6) Existing structural problems.

c) An inspection from the interior of the home should include an examination of the following:

(1) Interior foundation wall type and condition.

(2) Electrical and plumbing utilities.

(3) Moisture problems.

d) Make any necessary repairs before installing insulation.

2. Moisture Inspection and Repair

a) All units must be inspected for problems associated with excess moisture.

b) Identification of potential moisture problems shall be documented in the client file.

c) Repair any moisture problems that will degrade or diminish the effectiveness of weatherization measures.

d) For crawlspaces, install a 6 mil polyethylene moisture barrier on the dirt floor. This barrier should overlap at least 6 inches at joints and the polyethylene should extend 6 inches up the crawlspace wall. Note: If the entire dirt floor is not accessible, cover as much as possible.

e) For basements with dirt floors, whenever feasible, install a 6 mil polyethylene moisture barrier on the floor. This barrier should overlap at least 6 inches at joints and the polyethylene should extend 6 inches up the crawlspace wall. Lay rolled roofing on top of this polyethylene to provide a safe walkway for clients. Talk with clients about where this rolled roofing should be placed and try to minimize the amount used.

3. Wall Moisture Barrier

a) If there is evidence of water leakage or moisture coming through the foundation wall from the exterior, a moisture barrier must be attached to the sill plate in a manner that drains the moisture behind the insulation, and covers the insulated section of the foundation or crawlspace wall.

4. Treatment of Other Hazards

a) Use appropriate personal protective equipment and work practices in the presence of animal or insect hazards. Ensure personal safety during work and exercise the walk-away policy when appropriate.

b) Repair any rotted, broken, or damaged structural components.

5. Defining the Thermal Boundary

a) If the basement or crawlspace houses a heating system and other appliance, it should be treated as a conditioned area. In this case – the most common – the basement or crawlspace walls are part of the boundary of the conditioned envelope. Therefore, it is preferred to air seal and insulate the basement or crawlspace walls because this strategy encloses the furnace, ducts, pipes, water heater, and other appliances within the conditioned envelope.

b) Basements and crawlspaces should be tested using zonal pressure diagnostics when the housing construction type or the air leakage rate indicates that there may be hidden air leakage or bypass pathways into the basement or crawlspace. This test should be used to determine quality and completeness of air leakage and bypass sealing, prior to, and then after, installing insulation. In addition, this test can help determine the appropriate location of the thermal boundary.

c) If the appropriate thermal boundary is determined to be the basement or crawlspace wall, rather than the floor above the basement/crawlspace, then the basement or crawlspace wall should be sealed, as necessary, before any insulation is installed on these surfaces.

G. Foundation Insulation Installation Methods

1. Storage Space

a) Where the basement or crawlspace is being used for storage, subgrantees should request the client remove storage items from the area.

b) In cases where the client is physically unable to perform this task, subgrantees should include the removal of items in the cost-effective analysis of installing insulation, and proceed with the measure if it is cost-effective (savings-to-investment ratio of 1.00 or greater).

2. Materials

a) Interior basement wall insulation:

(1) If the wall is studded out on the interior, it may be filled with unfaced fiberglass batt of an appropriate thickness or with vinyl-faced fiberglass (metal building insulation).

(2) Vinyl-faced fiberglass (metal building insulation) may be fastened at the band joist area and hung down four feet.

(3) Interior rigid insulation may be glued and fastened to the basement wall.

(4) Costs associated with this measure should be included in the cost-effective analysis and proceed with the measure if it is has a savings-to-investment ratio of 1.00 or greater and cost controls will permit installation.

b) Exterior basement wall insulation:

(1) Foundation panels (factory pre-finished on exterior) may be used if they are glued and fastened, has drip caps installed, and is sealed around windows. They must extend at least 6 inches below the finished grade.

(2) Extruded polystyrene may be used that is not pre-finished if glued and fastened, has drip caps installed, and is sealed around windows. The insulation must extend at least 6 inches below the finished grade. The exterior surface of these panels must be covered with a material that will protect it from ultra-violet light.

(3) Costs associated with this measure should be included in the cost-effective analysis and proceed with the measure if it is has a savings-to-investment ratio of 1.00 or greater and cost controls will permit installation.

c) Insulation Coverage

(1) Insulation must be installed in a manner that provides as continuous a thermal boundary as possible.

(2) Perimeter insulation must not be installed in a manner that excessively compresses the insulation material.

d) Rim Joist Insulation

(1) Rim joist insulation must be a minimum of R-10.

(2) Fiberglass, rigid, or foam insulation may be used for this application. Whichever is used must result in a savings-to-investment ratio of at least 1.00.

(3) If there is significant air leakage, the band or rim joist area must be properly sealed before the insulation is installed.

(4) The insulation must be secured in a permanent manner.

e) Foundation Insulation

(1) Route any exhaust fans to the outside using dampered vents, smooth-bore rigid pipe, and an appropriate termination fixture.

(2) If necessary, repair or replace exterior doors or door components to reduce air leakage. If necessary, replace all missing glass and repair or replace window components to reduce air leakage.

(3) Foundation walls should be insulated so that no portion above grade is left uninsulated.

(4) Fiberglass insulation must not be left exposed in living areas.

(5) Mechanical fasteners must be used to secure perimeter insulation in a permanent manner.

(6) Basement wall insulation must be a minimum of R-7.5.

f) Interior Wall Installation

(1) Stud out wall and insulate with fiberglass or use rigid insulation glued and fastened.

(2) An alternative method for installing perimeter insulation is to attach metal-building insulation at the floor above the rim, so that the blanket extends from the

floor above four feet down the foundation wall. It should be run horizontally in a continuous manner to eliminate as many seams as possible. The blanket may be slit at each floor joist to allow installation in a manner that minimizes gaps around the joist. The bottom of the bottom of this fiberglass batt insulation should be air sealed to the wall with a strip of wood nailed to the foundation or by sealing the vinyl facing to the wall with adhesive caulk.

(3) Other insulation types and methods may be used with the approval of the DNR/EC.

g) Exterior Wall Installation

(1) Foundation insulation may be installed on the exterior, but this requires digging a one-foot deep trench around the foundation. If this method is used, the rigid insulation must be extruded polystyrene at least one-inch thick with an R-5 and it must be protected from sunlight and exterior mechanical damage by an appropriate rigid material.

3. Crawlspace Insulation

a) Separate an unconditioned crawl space from an adjoining conditioned basement with suitable materials.

b) Seal all direct air leakage sites into the crawl space.

c) Seal all bypasses and chases into and through the conditioned areas of the house.

d) Route any exhaust fans to the outside, using dampered vents and smooth bore rigid pipe and an appropriate termination fixture.

e) Install perimeter insulation from the band joist to the crawl space floor. The crawl space wall insulation shall extend downward 1) to a distance that is two feet below the exterior grade or 2) to the crawlspace floor and then horizontally across the floor for two feet, which ever is appropriate. Mechanically fasten the insulation and seal all joints with tape.

f) An alternative method for installing interior perimeter insulation is to attach metal-building insulation at the floor above the rim, so that the blanket extends from the floor above to four feet down the wall. It should be run horizontally in a manner that minimizes the number of seams. The blanket may be slit at each floor joist to allow installation in a manner that minimizes gaps around the joist. This insulation should extend downward to a distance that is two feet below the exterior grade or to the crawlspace floor and then horizontally across the floor for two feet, which ever is appropriate. Mechanically fasten the insulation and seal all joints with tape.

H. Floor Insulation

1. Inspection and Repairs

a) Precautions must be taken to insure adequate combustion air is being supplied, through non-operable vents, for combustion appliances in crawl spaces.

2. Moisture Inspection and Repairs

a) All units must be inspected for problems associated with excess moisture.

b) If floor insulation is installed over a crawlspace area, the crawlspace floor should be covered with a 6 mil polyethylene moisture barrier when conditions warrant. This polyethylene must be lapped at least 6 inches and joints and extended up the crawlspace wall by 6 inches.

c) Identification of potential moisture problems shall be documented in the client file.

d) Repair of moisture problems that will degrade or diminish the effectiveness of weatherization measures.

3. Defining the Thermal Boundary

a) If the basement or crawlspace houses a heating system and other appliance, it should be treated as a conditioned area. In this case – the most common – the basement or crawlspace walls are part of the boundary of the conditioned envelope. Therefore, it is preferred to air seal and insulate the basement or crawlspace walls because this strategy encloses the furnace, ducts, pipes, water heater, and other appliances within the conditioned envelope.

b) Basements and crawlspaces should be tested using zonal pressure diagnostics when the housing construction type or the air leakage rate indicates that there may be hidden air leakage or bypass pathways into the basement or crawlspace. This test should be used to determine quality and completeness of air leakage and bypass sealing, prior to, and then after, installing insulation. In addition, this test can help determine the appropriate location of the thermal boundary.

c) If the appropriate thermal boundary is determined to be the floor above the basement or crawlspace, rather than the walls of the basement or crawlspace, then this floor should be sealed, as necessary, before any insulation is installed under it.

I. Installation Methods for Floor Insulation

1. General Procedures

a) Install a minimum of R-19 insulation between the floor joists.

b) The insulation should be installed without voids or gaps. Fit insulation tightly around cross bracing and any obstructions.

c) Floor insulation must be fastened securely in place with wire fasteners, nylon mesh, or other appropriate methods. Friction fitting or stapling of floor insulation is not considered an appropriate method for securing the material. Do not support insulation with Tyvek or Typar sheeting stapled to the bottom edges of the joists.

d) Install insulation so that it is in contact with the underside of the sub floor above.

e) Faced fiberglass insulation must have the facing upward toward the heated area.

f) Ensure that floor insulation is in direct contact with the rim joints. If the dwelling is balloon framed, air seal the bottom of the stud cavities prior to installing insulation.

g) Fiberglass insulation must not be left exposed in living areas.

2. Materials

a) Fiberglass, faced or unfaced, insulation is preferred for perimeter and floor insulation material.

b) It is preferred that vinyl faced insulation not be used for floor insulation.

3. Insulation Coverage

a) Floor insulation must be installed in a manner that provides as continuous a thermal boundary as possible.

b) Floor insulation must not be installed in a manner that excessively compresses the material.

4. Storage Space

a) Where the basement or crawlspace is being used for storage, subgrantees should request the client remove storage items from the area.

b) In cases where the client is physically unable to perform this task, subgrantees should include the removal of items in the cost-effective analysis of installing insulation, and proceed with the measure if it is cost-effective (savings-to-investment ratio of 1.00 or greater).

5. Ducts and Pipes

a) When floor Insulation is installed, ductwork below the floor insulation must be sealed and insulated.

b) When floor Insulation is installed, any water pipe that is susceptible to freezing, and all furnace supply and return ducts below the insulation, must be insulated as part of the floor insulation measure.

c) Do not insulate over pumps, valves, pressure relief devices or vents; do not insulate over heat tape unless manufacturers' specification indicate that such insulation is safe.

6. Crawlspace Ventilation

a) Conditioned crawl spaces:

(1) If crawlspace walls are insulated, the crawlspace shall not be vented to the outdoors.

b) Unconditioned crawl spaces:

(1) Crawl space ventilation is not necessary if the crawl space is well drained and dry.

c) Crawlspace vents shall be louvered and screened or otherwise designed to prevent the entry of snow, rain and critters into the building.

d) If operable crawlspace vents are installed, the client must be informed of the benefits of closing the vents in winter and opening the vents in summer.

e) If excess ventilation is present, it is preferred that it be closed off with removable rigid insulation. Where possible, close off vents on the windward side of the crawlspace. Do not close off combustion air vents.

VI. Mobile Home Requirements

The same general procedures described in all other sections of these WAP Standards shall apply to mobile homes unless otherwise stated or stated more specifically in this section.

A. Measure Protocol—(See NEAT/MHEA Recommendations on page 103).

B. Inspections and Repairs

1. General Information

a) The structure shall be properly supported, leveled, and restrained (if required) at the homeowner’s expense before weatherization measures are installed.

b) Structural problems affecting insulation measures must be completed prior to installing insulation.

c) Belly rodent barrier repairs must be repaired if insulation will be installed or if significant air leakage is occurring.

2. Moisture Problems

a) If moisture problems are present in the ceiling or sidewalls, insulation should not be ' added until the moisture source and/or site of penetration, including leaks, is identified and eliminated.

b) Exhaust-fan ducts terminating in spaces such as ceiling cavities or crawl spaces shall be extended to terminate directly to the outdoors, and sealed to prevent exhaust air from returning back into the conditioned space.

3. Electrical Inspections

a) In units that are receiving insulation measures, electrical wiring and the electrical circuit breaker/fuse box must be assessed for adequacy as follows:

(1) #12 Aluminum or #14 copper wiring must be protected with 15 amp fusing or breakers;

(2) Care must be taken to ensure that electrical wiring was not damaged during insulation work. This can be done by testing electrical outlets and switches following completion of work.

b) If there is reason to believe, before or after installing wall insulation, that a mobile home has aluminum wiring; it is recommended that an electrical inspection be performed by a licensed electrician following the completion of the insulation work.

c) The client should be asked about any known existing electrical problems

C. Air Leakage Reduction Requirements

1. General Requirements

a) Except for the sealing of ductwork and large holes to prevent insulation from entering the living space, all insulation measures should be completed before additional air sealing work is done, whenever possible.

b) Air sealing activities should comply with the cost-effective air sealing guidelines in Section III of these standards.

c) Air sealing activities should comply with the Building Airflow Standard (BAS) procedure and calculation in Section III of these standards.

d) Air leakage reduction measures shall not be installed when the starting CFM_{50} measurement is below the calculated BAS, except for the following:

(1) Ductwork sealing.

(2) Insulation preparation work.

(3) Major repairs.

(4) Air sealing work that is necessary to block moisture migration into ceilings and walls.

e) Air leakage installations that are done to address client comfort (for example, storm window near reading chair, jamb weather-strip kit on door near reading chair, etc.) must have a brief explanation documented in the client file.

f) Snap fasteners and/or weather-stripping shall be used whenever possible to reduce air leakage and/or to stop water from entering primary windows.

g) Major air leakage problems around single pane windows that cannot be eliminated with sidewall insulation or snap fasteners, shall have an interior storm window installed, or the window replaced, whichever is most cost-effective.

h) It is recommended that caulking be done around all interior casing when there is an interior storm window.

i) When accessible, the joint between the two sections of a double-wide must be filled and sealed from underneath the structure.

j) Large holes in water heater closets with an exterior wall must be sealed, with care taken not to seal off combustion air from the outside.

D. Insulation

1. General Information

a) Insulation shall be installed only in areas of the mobile home envelope that separate conditioned from unconditioned space.

2. Ceiling Insulation

a) Recessed lighting fixtures and fan/light combinations that are Type-IC rated by UL may be covered with insulation.

b) Ventilation fans may be covered with insulation if all holes and penetrations are sealed with a nonflammable sealant.

c) Thermal insulation shall not be installed within 3 inches of fans, lights, and heaters that are not Type-IC.

d) All combustible insulation materials shall be kept at least 2 inches from metal flues and chimneys.

e) The ceiling and roof condition must be inspected and assessed before installing insulation.

f) If cost-effective, ceilings that appear weak shall be repaired or reinforced, especially in heavy snow load areas, before installing insulation.

g) Combustion appliance vent blocking is required when insulation is installed, except where combustion air is pulled through a combustion air pipe that surrounds the combustion appliance vent pipe (concentric pipe system). Follow manufacture's recommendation for clearances between vent and combustible insulation.

h) Ceiling insulation must be installed in such a manner that ensures complete coverage over heated areas, except those areas requiring and receiving a technical waiver.

i) Average insulation densities for loose fill insulation installed in mobile home ceiling cavities shall be:

   (1) Fiberglass – 1.25 to 1.75 pounds per cubic foot.

j) Mobile home ceilings shall not be dense-packed or over filled so as to create ceiling structural problems.

k) If an interior drill-and-blow method is used for installing insulation, holes must be plugged and sealed properly. In addition, the whole pattern must be adequate to ensure complete coverage.

l) If an exterior installation method or side-opening method is used, all roof penetrations and areas of potential leakage must be sealed with elastomeric sealant (when compatible with roof materials), or with other equivalent sealant, as necessary. Areas that are to be patched must be cleaned to the metal roof surface.

m) Fiberglass insulation material is preferred for use in mobile home ceilings.

E. Ductwork

1. General Requirements

a) Mobile home belly return air systems must be permanently sealed from the living space. A living-space return air system must be created by either removing the furnace closet door or installing an adequately sized return air grille(s) in the furnace closet door; allowing for return airflow under closed bedroom and bathroom doors; and sealing the return air grill in the furnace closet.

b) For duct leakage, ductwork sealing and insulation, follow the instructions in Section IV.

2. Crossover Duct Repair and Treatment:

a) Crossover ducts shall be installed in a manner that prevents compressions or sharp bends, minimize stress at connections, avoid standing water, and avoid excessive length. When skirting is not present, the crossover duct shall be protected against rodents, pets, etc.

b) Flexible crossover ducts shall have a minimum R-8 insulation. They shall be secured with mechanical fasteners (for example, stainless steel worm drive clamps, plastic/nylon straps applied with a tightening tool, etc.) and sealed with mastic or aluminum foil backed butyl or equivalent pressure-sensitive tape.

c) Existing flexible crossover duct with an insulation of R-4 or less which has been damaged may be replaced with new flexible duct with R-8 insulation.

d) The crossover must be replaced if the inner lining is brittle or made of mesh. If in doubt, replace it. In many cases, a leaky crossover can be repaired by cutting out the section of duct containing the leak. A fabricated sheet metal sleeve can be inserted between the remaining pieces of crossover duct. The metal sleeve must be attached to the flex duct crossover using ratcheting plastic straps.

e) Crossover ductwork must be appropriately secured above the ground. It may be supported by strapping or blocking.

f) Flexible duct shall not be allowed to sag more than 12 inches for a span of eight feet.

g) Fiberglass (with the exception of duct board) shall not be left exposed in ductwork.

h) Any portion of the ductwork that extends beyond the last register or grille may be sealed.

i) Trunk end sweeps are only allowed if it is determined that duct air leakage reduction will result from installation.

(1) End sweeps shall be made from sheet metal or aluminum valley flashing. Two-part foam may not be used unless it is adequately protected with a fifteen-minute fire rated material. Any metal sweeps must be mechanically attached to the duct system. Gaps between the sweep and the duct must be sealed with mastic.

F. Floor (Belly) Insulation

1. Floor Insulation Requirements

a) Belly rodent barriers must be inspected for general condition, structural strength, and major air leakage, prior to installing insulation.

b) Necessary belly rodent barrier repairs must be made if additional insulation will be added or if holes in the belly allow significant air movement between the belly cavity and the outside atmosphere.

c) Belly cavities must be inspected to determine the location of the plumbing, any existing plumbing leaks, and the R-value of existing insulation. Leaks should be fixed prior to weatherization

d) If water pipes are located at the bottom of the belly rodent barrier and it is not possible to get at least two inches of insulation between the pipes and the rodent barrier, then the following must be attempted, if cost-effective and feasible:

(1) The pipes must either be insulated with additional insulation, either inside the belly or on the exterior of the rodent barrier; or

(2) The pipes shall be moved closer to the floor above or the insulation above the pipes should be removed.

(3) *Note*: If these items cannot be completed, then the belly shall be insulated using the perimeter method.

e) Belly insulation shall be installed only after all repairs have been made, major holes in the rodent barrier and floor have been sealed, and all ductwork has been sealed according to Section IV.

f) Belly insulation must be installed in such a manner that ensures complete coverage under heated areas except those areas requiring and receiving a technical waiver.

g) Holes that have been made in belly rodent barriers for the installation of insulation must be patched and sealed.

h) Rim joists may not be drilled if they are determined to be a structural component of the foundation support system.

i) Average insulation densities for loose fill insulation installed in mobile home bellies shall be:

(1) Fiberglass – 1.25 to 1.75 pounds per cubic foot

j) Bellies shall not be dense-packed or over filled so as to create undue stress on the belly rodent barrier.

2. Floor Insulation Methods

a) Fiberglass is the preferred insulation material for mobile home bellies.

b) Bellies that are 8 inches height and less in the center area shall be filled entirely with insulation blown at the required densities.

c) Bellies that are greater than 8 inches in height at the center area shall be insulated using the perimeter method only after attempts have been made to bring the rodent barrier closer to the floor above. This must be done with care to avoid damaging the duct trunk line or water lines in the belly.

d) Access through the rim joist and the use of a metal fill tube is preferred for installing mobile home belly insulation whenever possible.

e) If bellies cannot be insulated through the rim joist and must be insulated from underneath, the use of the insulation hose or a large diameter fill tube is preferred; a 90-degree nozzle may not be used.

f) When insulation has to be installed from underneath the belly, the installation of a 6 mil vapor barrier on the ground by the first person to go underneath is preferred, in order to reduce health risks to the installers from animal feces.

g) The preferred methods of securing belly patches are through the use of adhesives, clinch staples, screws and lath strips whenever possible to provide a lasting patch.

h) Preferred patching materials for large holes in belly rodent barriers include insulated sheathing board, fiberboard, and nylon reinforced belly bottom material specifically manufactured for mobile homes.

i) Ductwork shall be inspected for insulation that might have accidentally entered during insulation work, and the furnace is cycled to assess proper operation.

j) Upon completion of insulation work, rim joists that have been drilled shall be plugged with a wood plug. The plug shall be sealed in the hole with an adhesive compound.

G. Mobile Home Belly-Return Conversion

1. General Requirement

Belly-return systems in mobile homes are notoriously leaky. These leaky return systems can significantly increase the space heating costs and lead to thermal discomfort and indoor air quality problems.

The best practice and required action is to convert the belly-return systems to a living space return system. Follow the procedures below:

a) Add a grill with at least 200 in^2 of net free area to the furnace closet door.

b) Block all floor return registers with a durable and tight air barrier being careful to find hidden registers under built-ins, behind furniture, and in kitchen kick spaces.

c) Completely block all floor openings in the furnace closet using a fire retardant air barrier, being careful to not seal the combustion air inlet.

d) Check the temperature rise of the furnace to ensure that the airflow is not restricted. The temperature rise should be within the range specified on the manufacturer's label or between 40° and 80° F.

(1) Inspect the plenum/furnace joint before measuring the temperature rise. Repair this joint, if needed, before measuring temperature rise.

(2) Make sure all interior doors are open, except the furnace closet door.

(3) Close the furnace closet door completely.

(4) Turn on the furnace and allow the temperature of the supply air to stabilize. Measure the temperature at the register closest to the furnace, making sure that the airflow to this register is not blocked and that there is no significant duct leakage between the furnace and your thermometer.

(5) Subtract the house air temperature – the return air – from the supply air temperature. The difference is the temperature rise.

(6) If the temperature rise is greater than the recommended range the airflow is restricted by an:

(a) Undersized opening in the furnace closet door, or

(b) Another restriction in the ductwork.

(7) If the temperature rise is less than the recommended range, there might be:

(a) Significant leakage at the furnace/plenum joint, or

(b) Significant leakage in the duct between the furnace and your supply air temperature measurement.

(8) If the temperature rise is out of range, repair the cause by removing any restriction to airflow or repairing leaks. Check the temperature rise again. Once the temperature rise is within the recommended range, move on to the next step.

e) Measure room-to-room pressure differences and relieve pressure differences that are greater than 3 Pascals.

(1) Close all interior doors. Measure the pressure difference across all interior doors. Pressure test and record measurements for all rooms with reference to the main body of the house.

(2) Take action if room pressure difference exceeds 3 Pascals. Provide pressure relief by:

(a) Opening the door slightly while measuring the pressure difference across the door. Open the door until the pressure difference is 3 Pascals or less and measure the square inches of opening. This is the number of square inches:

(i) The door must be undercut.

(ii) A direct grille, offset grilles, or jump duct must be installed properly relieve the pressure imbalance caused by the distribution system when the door is closed.

f) Return dwelling to the pre-test condition.

H. Sidewall Insulation

1. General Requirements

a) Mobile home sidewalls should be insulated when doing so will not adversely affect average costs per home.

b) The exterior siding and the interior wall materials must be inspected prior to the installation of insulation.

c) Weak or damaged wall materials must be repaired or reinforced prior to installing insulation.

d) Electrical precautions:

(1) Electrical wiring and the electrical circuit breaker/fuse box must be assessed for adequacy. The client should be asked about any existing electrical problems, especially in the wall outlets or switches.

(2) If aluminum wiring is present, extra care must be taken to insure the electrical system is not damaged during insulation work. The following steps must be taken:

(a) Each cavity that contains an outlet, switch, or light fixture should be clearly identified and marked on the outside siding prior to the installation of the insulation, and these cavities should be carefully tubed rather than stuffed with a batt or, if excessive movement of the wires will still occur, then the cavity should not be insulated and;

(b) Each outlet, switch, or light fixture must be checked for proper operation immediately following the completion of the insulation work with a receptacle tester.

(3) If any one of the above two steps cannot be completed, the sidewalls shall not be insulated and documentation stating the reason for omission must be placed in the client file.

e) Installing insulation above windows and doors is usually not feasible or cost-effective and is not required in mobile homes.

f) Mobile home sidewalls shall not be dense-packed or over filled so as to create siding or interior wall structural problems.

2. Sidewall Insulation Methods

a) Vinyl faced fiberglass batt insulation and loose fill fiberglass are the preferred insulation materials for mobile home sidewalls.

b) The batt-stuff method is the favored technique for insulating wall cavities.

c) For cavities that cannot or should not be insulated with the batt-stuff technique, the fill-tube method with loose fill fiberglass is recommended.

d) If there is reason to believe, before or after installing wall insulation, that a mobile home has aluminum wiring; it is recommended that an electrical inspection be performed by a licensed electrician following the completion of the insulation work.

I. Water Pipe Insulation

1. General Information

a) Water pipes that have not been covered by under-floor insulation should be insulated to a minimum of R-3 by the owner.

b) The piping shall be free from water leaks and properly secured to support the weight of the piping and insulation.

c) The insulation product may be either flat and capable of being molded to the outside surface of common pipe size, or preformed to fit standard pipe diameters. If the product is preformed, dimensions shall be appropriate for the pipe size.

d) If the insulation is exposed to the weather, it shall be resistant to degradation from moisture, ultra-violet light, and extremes in temperature, or a jacket or facing shall be installed that protects the insulation from these conditions.

J. Water Heater Closets

1. General Information

a) At a minimum, water heater closets with an exterior wall must be treated as follows:

(1) The exterior access door and associated exterior walls of closets containing electric or gas water heaters shall be insulated, if possible. If the door and associated wall can be insulated, the water heater shall not be wrapped with insulation.

(a) Cover air vents if they are present in the door or associated exterior wall.

(b) Bring combustion air from underneath the belly or through the skirting by installing an appropriately sized metal chute with a rodent barrier.

(2) If it is not possible to insulate the closet door and associated wall area:

(a) The tank should be wrapped with an insulation blanket. Please refer to Section IV for the procedure.

(b) Large holes in the closet walls that allow air leakage into the interior must be sealed.

(c) All plumbing within the closet that is susceptible to freezing must be insulated.

(d) An adequate amount of combustion air must be provided to gas water heaters.

K. Combustion Systems

1. General Information

a) If interior combustion air is used for the furnace, replacement with a sealed combustion (direct-vent) furnace is required.

VII. Multi-family Buildings

A. General Requirements/Information

1. Prior Approval

a) No multi-family project may commence without the prior written approval of the project from DNR/EC.

2. Eligibility

a) Weatherization work shall be performed in the entire building provided the building is qualified based on applications that meet the 66-2/3 percent eligibility guideline. However, DOE offered flexibility by adding certain eligible type of large multi-family buildings to the list of dwellings that are exempt from the 66-2/3 percent requirement. In these large multi-family buildings, as few as 50 percent of the units would have to be certified as eligible before weatherization. This exception would apply only to those large multi-family buildings where an investment of DOE funds would result in significant energy efficiency improvement because of the upgrades to equipment, energy systems, common space, or the building shell.

3. Expenditures/Funding Issues

a) Landlords must contribute at least 25 percent of the cost of the work.

b) Only Energy Efficiency Measures (EEM) with a SIR of 1.0 or greater may be performed. However, if the SIR is less than 1, the owner has the option to buy down in order to bring the SIR to 1.0 or greater.

4. Building Measures

a) All work must be cost-justified using the EA-QUIP auditing tool or other approved software by DNR/EC.

b) A person certified to use the EA-QUIP auditing tool or other approved software must perform the inspection of the building.

c) All applicable ECMs specified in the audit must be evaluated and performed unless a waiver is approved by DNR/EC.

d) ECMs must be performed in order of their cost-effectiveness from highest to lowest SIR.

B. Tasks and Analysis for Preparing the Report

1. Energy Consumption and Facility Data

a) The auditor shall thoroughly evaluate energy, water and sewage costs and consumption, demand and time-of-use data in order to properly evaluate the economics of specific energy efficiency measures and to formulate an accurate energy/demand baseline. The baseline shall be weather-normalized using a heating degree-day adjustment factor and shall be based on at least 12 months, but preferably 2 years of utility data.

2. Inventory Existing Systems and Equipment

The auditor shall compile and deliver an inventory based on a physical inspection of the major electrical, plumbing, HVAC and other mechanical systems, as well as building shell systems including:

a) Cooling and cooling distribution systems and related equipment.

b) Heating and heat distribution systems.

c) Automatic temperature control systems and equipment.

d) Outdoor ventilation systems and equipment.

e) Exhaust systems and equipment.

f) Domestic hot and cold water systems.

g) Electric motors, transmission and drive systems.

h) Interior and exterior lighting.

i) Water usage equipment.

j) Rated and performance insulation values at walls, floors, and attics.

k) Estimated natural infiltration rate for all buildings.

3. Inventory Data

The auditor shall evaluate the following data for performing the inventory:

a) The actual loads, equipment sizing, operating efficiency, and hours of operation for each system.

b) A list of major air leakage sites and description of how natural infiltration was estimated.

c) Current operating condition for each system.

d) Remaining useful life of each system (exclusive of premature equipment failure).

e) A catalog of current indoor air quality and comfort problems in the buildings.

f) An evaluation of feasible replacement/upgrades to address the efficiency, indoors air quality and comfort concerns that were identified.

4. Diagnostics

The auditor shall:

a) Perform diagnostic testing on equipment. These tests shall include combustion appliance zone testing for back drafting potential:

(1) Standard and worst-case draft testing. See Section II for testing information.

(2) Combustion efficiency analysis.

(3) Ambient carbon monoxide and flue-gas testing.

b) Perform additional diagnostics to help identify potential ECMs for installation or implementation at the building, including potential solutions for indoor air quality and comfort concerns.

c) Complete all inputs required by EA-QUIP analysis tool or other approved software and otherwise ensure an accurate audit of the multi-family structure.

VIII. General Information & Miscellaneous Standards

A. General Information

1. Material Standards

Only weatherization materials that are listed in the most current Appendix A - Standards for

Weatherization Materials, 10 CFR Part 440, or that meet or exceed the standards prescribed in Appendix A, shall be installed as weatherization materials. Materials shall be installed according to State and local codes. Materials shall be installed according to manufacturers' instructions unless specified otherwise.

2. Surface Preparation

Surfaces must be appropriately cleaned, prior to installing caulking or adhesive-backed materials.

3. Untreated, Exposed Wood

All exposed wood and raw edges that have been installed or modified by WAP efforts shall have a primer or sealant applied in such a manner that the client can finish the wood to match surrounding wood surfaces.

4. Insulation Levels

Contractors installing blown-in insulation must permanently fasten to the roof side of the attic access (or other accessible location specified by the agency) a signed certificate that attests to the company name, date installed, insulation brand name, R-value added, square footage, thermal resistance chart, conformance to federal specifications, and the number of bags installed in the attic and sidewalls.

B. Energy Audit Requirements

1. Field Audit

a) A field audit of each unit must be conducted and documented in the unit file.

b) The field audit must include:

(1) A client interview that is to include a discussion of client energy use habits, condition of the dwelling, operation of mechanical equipment, health and comfort problems and other information that may be useful to the auditor or the audit process. (See *Attachment 3-3.1 for the assessment form*);

(2) A health, safety, and hazards assessment of the heating unit as well as the combustion appliances;

(3) A cost-effective analysis using the approved energy audit system;

(4) An air leakage/ventilation assessment and Building Airflow calculation on each home (See *Attachment 3-3.2 for the assessment form* and *3.2 for the Final Inspection Form*);

(5) A ductwork assessment;

(6) An insulation assessment; and

(7) A general heat waste assessment.

(8) A mechanical systems audit and completion of the mechanical systems audit form on each home. See *Attachment 3-3.4 for the Missouri Weatherization Mechanical Systems Audit Form*.

c) The thermal boundary of each dwelling must be determined during the field audit. This includes the identification of each part of the thermal shell or envelope.

d) All building cavities that define the thermal boundary between the conditioned space and unconditioned must be inspected and measured for existing insulation R-values, structural integrity and the need for repairs.

e) The field audit must identify the most appropriate methods for:

(1) Reducing air leakage and convective bypasses, and

(2) Increasing the insulating value of thermal boundary surfaces, when appropriate.

2. Computerized Energy Audit

a) Each client file must have an accurate work order generated by the NEAT/MHEA computerized audit for single family dwellings. File information on multi-family dwellings will be determined by agency consultation with the Missouri Weatherization Assistance Program Administrator.

b) An acceptable work order means one for which all WAP installed measures have a cumulative Savings to Investment Ratio (SIR) of 1.00 or greater.

(1) Measures that cause the cumulative SIR values to be less than 1.0 are ineligible.

(2) Measures for which SIR values are 1.00 to 1.2 are optional in relation to maintaining necessary average costs per dwelling.

(3) Measures for which SIR values are equal to or greater than 1.3 are mandatory.

c) If the auditor is aware of more than one method of installing an energy conserving measure, he/she must be able to justify, in writing in the client file, the selection of a method that does not have the highest SIR of the possible methods.

d) If repairs must be done in order to protect the integrity of an eligible measure, the repair costs, to include material and labor must be included in the cumulative SIR

calculation. Repairs are limited to $600 in material or to the point where NEAT or other approved computerized audit computes a cumulative SIR of not less than one (1), whichever comes first. As an optional approach, agencies may include the repair cost to protect the integrity of an individual measure with that measure's individual SIR calculation.

e) Values and methods used for the State approved computerized audit will be periodically updated by either the subgrantee or statewide WAP committees as follows:

(1) Labor and material cost estimations used for the approved audit must be updated at least once each year and procedures used to derive these estimated costs must be documented by the subgrantee.

(a) Labor costs shall include fringe benefits as defined by the subgrantees accounting system.

(b) Insulation cost estimates must be based on at least the manufacturers recommended minimum installation density.

(2) A technical committee made up of representatives from the State subgrantees will determine and update each year:

(a) The typical service life of each energy-saving measure. The service life values must be discounted for use in the calculation of SIR in accordance with Department of Energy guidelines.

(b) A consistent method determining the cost of fuels to be used in the computerized audit.

C. Window and Door Standards

Windows and doors were once thought to be a major air-leakage problem. However, since the realization that most homes have gaps in the air barrier large enough to put your hand through, window and door air-sealing has been de-emphasized. The application of window measures should be governed by cost-effectiveness as determined by the NEAT computer audits or similar approved decision-making tools.

Windows' energy efficiency is improved in two primary ways: increasing thermal resistance and reducing air leakage. The limiting factors to the application of these measures are money and time. In the past, window measures, especially storm windows and replacement windows, were overemphasized.

Windows and doors remain very important building elements and their repair or replacement is often essential for a building's survival. However, like any repair measure, window and door rehabilitation should be limited to funds that are dedicated to repair work. Repairs must be

limited in a manner to maintain a cumulative SIR of 1 or greater. All tasks relating to window and door repair should be accomplished using lead-safe weatherization methods.

1. Primary windows

a) Window Assessment

(1) Windows must be assessed with the computerized audit to determine the need for potential repair for air leakage reduction and comfort-related problems.

(2) All existing egress windows must remain operable.

(3) Non-operable windows may receive air leakage work based on the guidelines in Subsection III and in the following air sealing priority: big holes first, then attic, then basement, then windows/doors/interior).

b) Subgrantee installed storm windows in kitchens, baths and other high moisture areas should be operable if they provide the only source of fresh air ventilation into the space.

2. Window Air Leakage

With the exception of broken glass or missing panes, windows are rarely the major source of air leakage in a home. Window air-leakage measures are marginally cost-effective.

The measures listed below may be addressed as energy efficiency if they are found to be cost-effective through the use of the air sealing guide line outlined in Section III. Otherwise, they are repair items, performed to increase building durability and are part of the cumulative SIR calculation of 1 or greater:

a) Replace missing or broken glass or glass that is cracked and noticeably separated that affects the structural integrity of the window. Use glazing compound and glazier points when replacing glass. Glass cracks that are not noticeably separated may be neglected.

b) To prevent air leakage, condensation, and rain leakage, seal between window frame and other building materials on interior and exterior walls. Use sealants with rated adhesion and joint-movement characteristics appropriate for both the window frame and the building materials surrounding the window.

c) Replace missing or severely deteriorated window frame components, such as, stops, jambs or sills. Wood exposed to the weather should be primed and painted. Glazing window sashes is best accomplished as part of a comprehensive window rehabilitation project. Re-glazing wood windows may not be a durable repair without scraping, priming, and painting.

d) Window stops should be adjusted if large gaps exist between stop and jamb. Ensure that window operates smoothly following stop adjustment.

e) Large gaps between sash and sill and sash and stops may be weather-stripped. Meeting rails may also be weather-stripped or planed. Window weather-stripping is typically not cost-effective but maybe installed to solve a comfort problem.

f) Replace/repair missing or non-functional top and side sash locks, hinges or other hardware if such action will significantly reduce air leakage. Avoid expensive or time-consuming window-repair measures, implemented to solve minor comfort complaints.

3. Window Repairs

a) When feasible, window repairs must be done, instead of replacement, whenever the total cost of the repair is less than seventy-five percent of the cost of a replacement window.

b) Window glazing compound shall only be replaced if the existing glazing is deteriorated to the degree that the window glass is in jeopardy of falling out if the sash.

c) Window sashes are not required to be made operable unless stipulated by building codes.

4. Window Replacements

a) A window may be replaced if the SIR is 1 or greater when cost tested using the approved computerized audit.

b) Window replacements are generally not cost-effective energy conservation measures and are replaced only as emergency repair measures when the window is missing, or damaged beyond repair. When this type of replacement is necessary, replacement windows may be part of the incidental repairs that are cost-tested in the cumulative SIR and under the guidelines of total costs for incidental repairs.

c) Double-glazed replacement window units are preferred if their cost is justified by the computerized audit.

d) Window replacements must be based primarily on an energy-conservation decision process rather than client requests or aesthetics.

5. Storm Windows

a) Storm windows are generally cost-effective only if purchased at the right price. If storm windows are to be installed, select metal exterior storm windows with the following qualities:

b) Frame should have sturdy corners and not tend to rack out-of-square during transport and installation.

c) The gasket sealing the glass should surround the glass's edge and not merely wedge the glass in place against the metal frame.

d) Storm-window sashes must fit tightly in their frames.

e) The window should be sized correctly and fit well in the opening.

f) Storm windows shall be caulked around the frame at time of installation, except for weep holes that shall not be sealed. If weep holes are not manufactured into new storm window, weep holes shall be drilled into them.

g) Storm-window sashes must be removable from indoors.

h) New storm windows must not be used to replace existing storms if the existing storms are in good condition or can be repaired at a reasonable cost.

i) Wood storm window inserts should fit neatly within window frame with the appropriate turn buttons, latches or closing hardware.

j) Fixed storm windows must not restrict the existing capacity and access required for emergency exits.

6. Movable Window Insulation Systems

a) Movable window insulation systems are only allowed based on the following:

(1) The systems are determined to be cost-effective by an approved energy audit;

(2) For technical reasons, no interior or exterior storm windows are able be installed;

(3) All other weatherization measures with a higher SIR values exist or have been installed, and;

(4) The client has been trained in the operation of the movable insulation system.

7. Non-Allowable Window Materials

a) Tinted window films, all sun shields and heat reflective materials are not allowable WAP expenses.

8. Doors

Door measures are usually not cost-effective unless they have a very low cost. Doors have a small surface area and their air leakage is more of a localized comfort problem than a significant energy problem most of the time. However, door operation affects building security and durability, so doors are often an important repair priority.

a) Doors must be assessed to determine the need for repair, for air leakage reduction and comfort-related problems.

b) All existing egress doors must remain operable.

c) Non-operable doors may receive air leakage work based on the guidelines in Section III and in the following air sealing priority: big holes first, then attic, then basement, then windows/doors/interior).

9. Door Air Leakage

Door weather-strip, thresholds and sweeps are marginally cost-effective. These measures may be addressed if they are found to be cost-effective using the guidelines in Section III or they are isolated installation of to address client comfort.

a) Before installing weather-stripping, remove old weather-strip. Tighten door hardware and adjust stops so door closes snugly against its stops.

b) Use a durable stop-mounted or jamb-mounted weather-strip material to weather-strip the door. New weather-strip must form a tight seal (no buckling or gaps) when installed. Door should close without rubbing or binding on the stops and jambs.

c) Thresholds and door sweeps are installed to prevent infiltration and should not bind the door. Thresholds should be caulked at the sill and jamb junction.

10. Door Repairs

a) When feasible, a door must be repaired rather than replaced whenever the total cost of the repair is seventy-five percent or less than the cost of the replacement door.

b) Doors found in non-operable condition are not required to be made operable.

c) The following door repair items to improve home security, building durability and otherwise protect measures in the home may be implemented when included in the SIR cumulative calculation of 1 or greater:

(1) Replace missing or inoperable locksets.

(2) Reposition the lockset/strike plate.

(3) Install a modernization kit so that the door can be held in a tightly closed

(4) Reposition stops if necessary.

(5) Seal gaps between the stop and jamb with caulk.

11. Door Replacements

a) Doors may be replaced in the event they meet the energy efficiency standard of having a SIR of 1 or greater as evaluated with the NEAT computerized audit.

b) The cost of the purchase and installation of all hardware and the material associated with the replacement of a door must be included in the calculation of the SIR used to justify the door replacement.

c) Door replacements are rarely cost-effective energy conservation measures, therefore replacing should only be done when the door is damaged beyond repair. In this case, the door replacement is considered an incidental repair and is to be included in cumulative SIR calculation of 1 or greater to be allowable.

d) Observe the following standards when replacing exterior doors:

(1) Replacement doors must have a solid wood core or an exterior-grade foam core. Replace the door using a solid core or insulated door-blank or a pre-hung steel insulated door. Replacing an exterior panel door with another panel door is not allowed. All replacement doors must have three hinges.

(2) Replacement doors should not have glass panes, however, replacement doors may include one light (pane of glass) if the replaced door had one or more lights. A door viewer is the preferred installation.

e) Pre-hung replacement doors may be installed if determined to be more cost-effective than the repair of the existing door and frame, or the installation of a door that is not pre-hung.

12. Storm Doors

Replacement or repair to storm doors is not allowed.

D. Base Measures

Base measures are under consideration as allowable measures for the Missouri Weatherization Assistance Program and will be evaluated for implementation by the Technical Workgroup.

E. Subgrantee Housing Inspection Standard

1. General Requirements

a) Every dwelling must pass a thorough, quality-control inspection by the subgrantee before it can be reported as completed. The final inspection must certify that work was completed in a professional manner and in accordance with the Technical Standards. For a subgrantee that employs not more than three WAP staff, DNR/EC will allow the same person who performs the initial inspection to perform the final inspection. However, at least 5 percent of all final inspections must be double-checked by the WAP Director or another independent person.

b) Repeated attempts must be made by all subgrantee final inspectors to final-inspect homes that have all ECMs completed. Final inspection includes inspection of both the interior and exterior of the dwelling. These attempts at complete inspections must be documented in all client files.

c) DNR/EC recommends a minimum of three attempts (within a seven- to 14-day period) to contact a client in order to arrange a date for final inspection as appropriate. These attempts may take the form of three phone calls, three on-site visits, or a combination of phone calls and on-site visits equaling three attempts. Various attempts made at contacting a client within the same working day would qualify as one attempt only. If the client cannot be reached after three attempts, it is acceptable to conduct a final inspection as completely as possible from the exterior of the home.

d) In certain instances, clients do not have phone service and/or live a significant distance from a subgrantee's weatherization office. Under such circumstances, it is recommended that a letter or postcard be mailed to the client informing him or her of the intent to perform a final inspection, along with a request to contact the subgrantee to arrange a date to do it. If no response is received within seven working days from the date of mailing, it is acceptable to conduct a final inspection as completely as possible from the exterior of the home.

F. Client Refusal of Material Installation

Weatherization clients have the right to refuse specific weatherization work measures in full or in part. When a client refuses weatherization work, the subgrantee should make a reasonable effort, explaining the reasons for the specific weatherization measure, to convince the client to allow the measure to be installed. Failing this, the subgrantee must secure written confirmation

from the client, identifying the measure that was refused and the reason for refusal. This documentation must remain in the client file.

Weatherization measures are to be installed only by a representative of the subgrantee, such as crew members or contractors. The client or a third party cannot install materials except under the supervision of a subgrantee staff member.
When a client opts to refuse measures that are health and safety issues or that have considerable potential for maximizing energy savings, the subgrantee may reject the job completely.

G. DNR/EC Criteria to Pass Housing Inspections

The housing quality inspection forms are used by DNR/EC as a tool to help evaluate the weatherization measures applied to a home. This information should be helpful in determining the review process homes must undergo to be reported complete. See Attachments A & B for the DNR/EC Housing Quality Inspection Forms.

A home will fail DNR/EC inspection when any one or more of the following are noted:

a) Significant or recurring incidents of work measures/materials are being billed to the program, but not installed.

b) A recurring item that has been specifically identified in a previous monitoring letter, which formally warned the subgrantee that failure to perform the item would result in non-passage of the dwelling.

c) A work measure that is significantly below the required work standards or work that is performed substantially below what is considered professional, quality workmanship.

d) Visible or obvious health and safety hazards that were neglected or overlooked, not rectified as allowed under program parameters, or for which required health and safety diagnostic tests were not performed.

e) Energy efficiency measures installed or a total job completed that have an individual and/or cumulative SIR of less than 1.

f) Failure to perform required diagnostic tests as prescribed.

g) Expenses associated with a home that fails DNR/EC inspection may be withheld from the subgrantee's subsequent reimbursement until the home passes.

H. NEAT/MHEA Recommendations

1. Support Cost

a) DNR/EC recommends the inclusion of support cost entered into the NEAT/MHEA program to provide more accurate information on the total job cost to weatherize a home. A subgrantee accepting this recommendation should adhere to the following. The support cost:

(1) Should be the actual or the average estimated (pro-rated) for the year.

(2) Must be entered on NEAT/MHEA "Itemized Additional Costs" screen as "Support Cost."

(3) Should not be cost-tested, (select N for no) so that the cumulative SIR is not decreased.

2. **Added or Additional Installation Cost**

The NEAT/MHEA audit allows entry of added or additional installation cost on the screens for walls, attic areas, and foundation spaces. The cost is in addition to the base cost of measures that are contained in the material cost setup screen.

As an example, consider the base cost of attic insulation, calculated at a certain price per square foot, would cost $350 for a particular attic. Additional installation cost might include cutting a new scuttle hole, two vents, roofing tar and nails for a total of $150. When the additional installation costs are entered in the "Additional Installation Cost" column for the measure, the audit internally combines the two costs and cost-tests the attic insulation measure at $500 rather than at $350.

Adding the additional installation cost to an individual measure, as described above, may cause the measure's SIR to fall below 1. To provide for a consistent cost test of a measure, DNR/EC recommends entering the additional installation cost on NEAT/MHEA's "Itemized Additional Cost" screen and (select Y for yes) for cost testing. This method of entry impacts the cumulative SIR rather than the individual SIR, which supplements consistent service delivery.

I. NEAT/MHEA Requirements

1. Savings-to-Investment Ratio (SIR)

a) Individual SIRs must be 1 or greater; energy efficiency measures with an SIR of less than 1 are not allowed.

b) An actual pre-test blower door reading must be entered into NEAT/MHEA. NEAT/MHEA requires reasonable cost estimates for air leakage work and CFM 50 reduction targets. Guidelines to assist the air and duct sealing estimates are provided in Section III. The subgrantee is responsible for developing its own cost estimates and CFM 50 reduction targets based on historical data to ensure reasonable accuracy of the NEAT/MHEA inputs. Moreover, agency staff must analyze actual air leakage

reductions and costs to those estimated during the NEAT/MHEA audit run to see whether significant variations are occurring. This analysis will help identify where adjustments may be needed.

2. Cumulative SIR

a) The cumulative SIR of the measures recommended by NEAT/MHEA must be 1 or greater. The measures should be implemented in a descending order, beginning with the highest SIR, until all measures with an SIR of 1 or greater are implemented, or until budget limits are reached. **Subgrantees may set the SIR threshold above 1 for budget reasons, provided this threshold is applied consistently**. When budget limits are a barrier, measures with a higher SIR, but lower Btu saving, may be omitted in favor of measures with a lower SIR that are estimated to save a significantly greater amount of Btu's — provided each measure has an SIR of 1 or greater and the cumulative SIR remains at 1 or above. The criteria for the lower SIR substitution must be documented and maintained in the client file.

(1) As an example, Sill box insulation with an SIR of 8 and an annual savings of three million Btus may be omitted to allow implementation of wall insulation with an SIR of 4 and an annual savings of 24 million Btus.

b) Should the estimated cumulative SIR compute to less than 1, the following options are allowed:

(1) Carefully review the Recommended Measure List and cost estimates; especially in the incidental repairs, miscellaneous, and infiltration categories; to determine if there are possible measures and associated costs that could be eliminated, and rerun the audit to ensure that the cumulative SIR is 1 or greater;

(2) Reject the home for weatherization.

J. File Documentation and NEAT/MHEA Input Form

1. General Requirements

a) Client files must contain the following documentation: (1) copies of relevant field notes, (2) completed audit input/output printout, (3) dwelling sketch or diagram, (4) measures and materials list (the .REP file), (5) parameter inputs and (6) user comments. **Digital photos may be substituted for a building sketch or diagram provided the photos convey the required building information.**

b) DNR/EC recommends the use of the NEAT/MHEA Input Form. An alternative data collection form may be used provided the information collected is equivalent to that of the NEAT/MHEA Input Form.

K. Software Version & Configuration

The latest NEAT/MHEA version of 8.3 or software as authorized by DNR/EC must be used on all site-built and mobile homes. The NEAT/MHEA setup screens must be configured as follows:

1. Material and Labor Costs

a) Subgrantees must use material and labor costs that will reflect the cost of a measure as close as possible when completed.

b) All measures considered must include both material and labor costs when entered into NEAT/MHEA (i.e. infiltration, incidental repairs, miscellaneous, etc.).

2. Candidate Measure Selection

Subgrantees must follow the guidelines in the table below for selecting measures that NEAT/MHEA will consider for implementation. Mandatory measures should be checked as active. Optional measures may be checked at the agency's discretion and the Not Considered measures should not be checked as active in the setup screen.

NEAT

Mandatory	Optional	Not Considered
Attic insulation R-11	Thermal vent damper	Floor insulation R-30
Attic insulation R-19	Electric vent damper	Window sealing
Attic insulation R-30	IID	Window replacement
Attic insulation R-38	Electric vent damper IID	Low E windows
Fill ceiling cavity	Flame retention burner	Window shading
Sillbox insulation	High efficiency furnace	Sun screen fabric
Foundation insulation	Smart Thermostat	Sun screen louvered
Floor insulation R-11	Replace heatpump	Window film
Floor insulation R-19	Low flow showerheads	Tune-up AC
Wall insulation	Water heater replacement	Replace AC
Wall insulation R-11 batt	Lighting retrofits	Evaporative cooler
Duct insulation		Refrigerator replacement
Storm windows		
Furnace tune-up		
Replace heating system		
Water heater tank insulation		
Water heater pipe insulation		

MHEA

Mandatory	Optional	Not Considered
Wall Fiber Glass Batt in Addition	Wall Fiber Glass Wall Batt Insulation	General Heat Waste
Wall Cellulose Loose Insulation in Addition	Wall Fiber Glass Loose Insulation	General Air Sealing
Wall Fiber Glass Loose Insulation in Addition	Floor Cellulose Loose Insulation in Addition	Wall Cellulose Loose Insulation
Floor Fiber Glass Loose Insulation	Roof Cellulose Loose Insulation in Addition	Floor Cellulose Loose Insulation
Floor Fiber Glass Loose Insulation in Addition	White Coat Roof on Addition	Roof Cellulose Loose Insulation
Roof Fiber Glass Loose Insulation	Plastic Storm Windows	Add Skirting
Roof Fiber Glass Loose Insulation in Addition	Plastic Storm Windows in Addition	Add Skirting on Addition
White Coat Roof	Setback Thermostat	Replace Marked Doors (mandatory)
Replace Single Pane Windows	Lighting Retrofits	Replace Wooden Doors
Replace Single Pane Windows in Addition	Low Flow Showerheads	Replace Wooden Doors in Addition
Glass Storm Windows		Storm Doors
Glass Storm Windows in Addition		Storm Doors in Addition
Tune Heating System		Window Sealing
Water Heater Tank Insulation		Window Sealing in Addition
Water Heater Pipe Insulation		Add Awnings
Water Heater Replacement		Add Awnings in Addition
Replace Heating Systems		Add Shade Screens
		Add Shade Screens in Addition
		Evaporative Cooling
		Tune Cooling System
		Replace DX Cooling Equipment
		Refrigerator Replacement

Measures recommended as cost-effective may not always be implemented in some situations due to circumstances such as structural problems, client refusals, renter vs. owner-occupied dwellings, health and safety issues, inaccessible locations, and/or budgetary concerns. Sound judgment and good documentation must be included in the file when these circumstances exist.

3. Fuel Costs

Subgrantees must obtain fuel costs for their service area for all fuel types listed. Fuel costs in the area should be checked at least once a year (preferably during the winter months) and updated, if necessary. Fuel costs should be typical; in other words, avoid high or low short-term values.

4. Parameters

Subgrantees must use the parameters established by DNR/EC and shall not modify them unless authorized by DNR/EC.

5. Weather Data

Subgrantees must use the appropriate weather data that most closely matches the weather for their service area.

6. Measure Numbers for Walls, Attics and Foundation Spaces

Measure numbers group together building components (walls, attics and foundation spaces) that, are to receive the same energy conservation measure, or for which a single SIR will be determined. For example, attic components having the same measure number will receive an SIR and separate ranking from other attic components having a different measure number. Building components having similar construction and existing insulation levels must have the same measure number assigned.

7. General Heat Waste

Items entered as general heat waste should be cost tested. General heat waste materials include an insulated jacket for a water heater, pipe insulation on the first six feet of hot water pipes leading from a water heater and low-flow shower heads. These measures may be accessed through the "Baseloads" tab in the NEAT/MHEA audit.

8. Itemized Additional Costs

The following is a list of measures that can be entered into the “Itemized Additional Cost” screen along with an explanation of how they are to be used in the Missouri Weatherization Assistance Program.

a) Incidental Repairs - Items entered as incidental repairs must be cost tested (make appropriate selection). The cost entry must include both material and labor. These items will appear at the top of the Recommended Measure List and the value will be added to both the cumulative cost and SIR.

(1) Incidental repairs are limited to $600 in materials per home. A subgrantee is required to document and request approval for any incidental repairs requiring more than $600 in materials. Types of incidental repairs for homes include, but are not limited to, repair of solid-fuel heating equipment, repair of permanently installed electric-resistance heating equipment, heating system repairs and primary door and window replacement.

(2) Structural deficiencies, or other problems requiring extensive repair beyond WAP guidelines, should be noted on the energy audit and brought to the attention of the homeowner. Whenever possible, clients should be provided with suggestions about possible assistance programs or measures that might be undertaken. The following list includes, but is not limited to, common materials utilized in incidental repairs: lumber, roofing materials, flashing, siding materials, masonry supplies, hardware for door repairs, kitchen/bath exhaust fans and clothes dryer vents.

(3) Structural changes are not allowed under WAP rules. Examples include, but are not limited to, new interior partition walls, new roofs, suspended or false ceilings, construction of air-lock vestibules, first-time primary door or window openings.

b) Miscellaneous - Items entered as miscellaneous must be cost tested (select Y for yes). These items will appear at the top of the Recommended Measure List and their value will be added to both the cumulative cost and SIR.

c) Health and Safety - Items entered as health and safety do not need to be cost tested (make appropriate selection). These items will appear at the bottom of the Recommended Measure List, and their cost will be added to the cumulative cost but not the SIR. Allowable health and safety measures include:

(1) Cleaning and tuning the heating system when the SIR is less than 1. Repairing or replacing combustion venting, heating equipment, gas leaks, wiring, or the water heater.

(2) Alleviating moisture-related problems

(3) Installing combustion air, carbon monoxide alarms, heat source barriers, smoke detectors or mechanical ventilation fans.

(4) Miscellaneous measures relevant to health and safety.

(5) A statewide limit for the average cost per home for health and safety abatement costs has been set at 10 percent of expenditures. DNR/EC recognizes that some hazards will be beyond the scope of the resources of the program to abate.

d) User-Defined - This entry is used for a weatherization activity that is not addressed by the standard NEAT/MHEA, provided an approximate annual savings associated with the measure in millions of Btu is known. At the present time, this entry should not be used, eliminating it from the Recommended Measures List.

9. Heating System Replacement

a) Required information must be entered in the NEAT/MHEA.

b) When a heating system's steady-state efficiency absolutely cannot be obtained, a default of 57 percent (based on a study from Nebraska and approved by U.S. DOE) may be used for the existing efficiency input into NEAT/MHEA. The need for this entry should be a rare occurrence and relevant to the age of the system.

c) A heating system has exceeded its useful and operational life expectancy when it satisfies at least one of the following conditions: (1) the heating system is inoperable and cannot be cost-effectively repaired or restored to efficient, operational and safe condition; (2) a structural degradation of the heating system has rendered it inoperable, potentially unsafe and not cost-effective to repair; (3) the heating system has been condemned (i.e. "Red Tagged") or identified by the auditor to have a faulty and/or cracked heat exchanger. The existence of a faulty or cracked heat exchanger must be documented either by a visible crack or hole, or through an approved diagnostic process specifically designed to identify cracked heat exchangers.

d) DNR/EC considers an operable, unvented space heater in a dwelling a potential health and safety hazard. U.S. DOE now distinguishes between primary and secondary unvented space heaters as heat sources (See *Attachment 3-1*).

e) A site-specific heating system replacement may be authorized by DNR/EC on a case-by-case basis.

10. Cooling System(s) Data

All homes audited with air conditioning must have the cooling system data entered into NEAT/MHEA.

11. Other

a) Structural deficiencies, or other problems requiring extensive repair beyond WAP guidelines, should be noted on the energy audit and brought to the attention of the homeowner. Whenever possible, clients should be provided with suggestions about possible assistance programs or measures that might be undertaken.

b) Structural changes are not allowed under WAP rules. Examples include, but are not limited to, new interior partition walls, new roofs, suspended or false ceilings, construction of air-lock vestibules, first-time primary door or window openings.

Department of Energy
Washington, DC 20585

WEATHERIZATION PROGRAM NOTICE 08-4
EFFECTIVE DATE: March 3, 2008

SUBJECT: SPACE HEATER POLICY

PURPOSE: To update the policy relating to space heaters for the Low-Income Weatherization Assistance Program (Weatherization). This policy supersedes the previous space heater policy issued by memoranda on March 18, 1992.

SCOPE: The provisions of this guidance apply to all grantees applying for financial assistance under the Department of Energy (DOE) Weatherization Assistance Program. This policy applies to electric and gas- and liquid-fueled space heaters only. Wood-burning stoves are addressed in separate guidance, which will be updated at a later date and will likely be expanded to include coal-burning stoves. This policy applies to electric and gas- and liquid-fueled space heaters whether the appliance is the primary or secondary heat source.

LEGAL AUTHORITY: Title IV, Energy Conservation and Production Act, as amended, authorizes the Department of Energy to administer the Low-Income Weatherization Assistance Program. All grant awards made under this program shall comply with applicable law including regulations contained in 10 CFR Part 440 (most recently issued June 22, 2006), and other procedures applicable to this regulation as DOE may from time to time prescribe for the administration of financial assistance.

INTRODUCTION: An estimated three million low-income households in the United States rely on space heaters as their primary method of heating their homes. An additional four million low-income households use space heaters as a secondary method of heating. Potential health and safety risks associated with the use of space heaters, especially portable and unvented devices include elevated levels of carbon monoxide, fire hazards, and excessive moisture resulting in mold and rot.

The previous space heater policy was issued March 18, 1992. Since then, Weatherization providers have improved their ability to reduce air infiltration in weatherized dwellings, which can exacerbate carbon monoxide and moisture hazards. Within the past ten years, local jurisdictions in at least 48 and 44 States have adopted the International Residential Code (IRC) and International Fuel Gas Code (IFGC), respectively, that include requirements related to space heaters. Most of these States have adopted the codes and enforce them statewide. The space

heater policy issued by this Weatherization Program Notice (WPN 08-4) is consistent with the IRC and IFGC and clarifies how to best address eligible dwelling units containing space heaters.

INCIDENTAL REPAIRS: Incidental repairs under the Weatherization Program are not affected by the policy contained herein. Agencies may continue making incidental repairs necessary to allow weatherization work to proceed safely, including to space heaters.

SPACE HEATER POLICY: Separate guidance is provided for vented space heaters and unvented space heaters.

Vented Space Heaters: Vented gas- and liquid-fueled space heaters should be treated the same as furnaces in terms of repair and replacement, as well as combustion appliance safety testing. This policy applies to vented natural gas-fired space heaters, vented propane-fired space heaters, and oil-fired space heaters (which are always vented).

Unvented Space Heaters: Separate guidance applies to electric space heaters and unvented gas- and liquid-fueled space heaters.

Electric Space Heaters – DOE will not permit any DOE-funded weatherization work other than incidental repairs on electric space heaters. DOE will not preclude the use of other funding sources for the replacement or major repair of electric space heaters, but the Department does not encourage it because of:

- The high cost of electricity as compared to fossil fuels;
- Lower output ratings (size);
- Risk of fire hazards; and,
- Inadequate electrical systems in older homes frequently cannot safely carry the power required to operate an electric heater.

Work on such systems may make local agencies liable for inadequate electric wiring and damages that may result.

Unvented Gas- and Liquid-Fueled Space Heaters – DOE will not permit any DOE-funded weatherization work where the completed dwelling unit is heated with an unvented gas- and/or liquid-fueled space heater as the primary heat source. This policy applies to unvented natural gas-fired space heaters, unvented propane-fired space heaters, and unvented kerosene space heaters. This policy is consistent with the IRC and the IFGC.

DOE strongly encourages removal of all unvented gas- and liquid-fueled space heaters and replacement with vented, code-compliant heating systems as a prerequisite to weatherization. However, DOE will allow unvented gas- or liquid-fueled space heaters to remain as secondary heat sources in single-family houses provided they comply with the IRC and the IFGC. DOE is allowing this flexibility primarily to provide low-income clients an emergency back-up source of heat in the event of electrical power outages. Therefore, preference should be given to code-compliant units that do not require electricity.

Specifically, any unvented gas- and liquid-fueled space heaters that remain in a completed single-family house after weatherization:

- Shall not have an input rating in excess of 40,000 Btu/hour;
- Shall not be located in, or obtain combustion air from sleeping rooms, bathrooms, toilet rooms, or storage closets, unless:
  - Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bathroom:
    - Has an input rating that does not exceed 6,000 Btu/hour;
    - Is equipped with an oxygen-depletion sensing safety shut-off system; and
    - The bathroom meets required volume criteria to provide adequate combustion air;
  - Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bedroom:
    - Has an input rating that does not exceed 10,000 Btu/hour;
    - Is equipped with an oxygen-depletion sensing safety shut-off system; and
    - The bedroom meets required volume criteria to provide adequate combustion air.
- Shall require the enforcement of minimum ventilation guidelines as determined by the greater of:
  - 15 cubic feet per minute (CFM) per person,
  - 15 CFM per bedroom plus one [(# of bedrooms + 1) x 15 CFM], or
  - .35 air changes per hour.

  The above minimum ventilation guidelines are natural ventilation rates, not with the house depressurized to -50 Pascal with a blower door.

  Alternately, the minimum ventilation guidelines in the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, may be used if the State desires.

DOE funds may only be used to replace the primary heating source. DOE funds may not be used to replace unvented space heaters to be left in the weatherized dwelling unit as secondary heating sources. For example, a home has several older gas- or liquid-fueled, unvented space heaters that do not comply with the International Residential Code because they do not have oxygen-depletion sensing safety shut-off systems. The Weatherization Program can replace the primary unvented space heater with a vented unit, but cannot expend DOE funds to replace one of the existing secondary space heaters with a code-compliant unvented unit with an oxygen-depletion sensing safety shut-off system. DOE will not preclude the use of other funding sources to replace secondary space heaters with code-compliant units.

The Manufactured Home Construction and Safety Standards require all fuel-burning, heat-producing appliances in mobile homes, except ranges and ovens, to be vented to outside. Further, all fuel-burning appliances in mobile homes, except ranges, ovens, illuminating appliances, clothes dryers, solid fuel-burning fireplaces and solid fuel-burning fireplace stoves, must be installed to provide for the complete separation of the combustion system from the interior atmosphere of the manufactured home (i.e., to draw their combustion air from outside).

Cost Effectiveness: Current regulations governing weatherization activities require that measures installed in a dwelling unit be selected on the basis of cost effectiveness, with the most cost effective installed first. Unvented space heaters have very high efficiency ratings because they discharge their exhaust gases directly into the space being heated rather than outside, allowing the energy embodied in the hot exhaust gases to be released into the heated space. Vented space heaters exhaust combustion products and considerable amounts of energy out of the residence, and, therefore, are far less energy efficient.

The replacement of an unvented space heater with a vented one may not be cost-justified through energy savings. However, DOE strongly encourages States to combine other weatherization measures and health and safety considerations with vented space heaters as replacements for unvented space heaters. In such instances, the heat energy demanded by the structure can be lowered by energy-saving, cost-effective weatherization measures so that total energy costs are less or the same, while the indoor air quality is greatly improved through the use of a vented space heater paid for with health and safety funds.

Smoke and Carbon Monoxide Detectors: Any space heater replacement or repair procedure should include inspection to ensure that working smoke and carbon monoxide detectors are installed on the same floor as the space heater. In instances where smoke and carbon monoxide detectors are not present or are not operating properly, new detectors may be purchased and installed with DOE funds. The purchase and installation cost of the smoke and carbon monoxide detectors may be charged to the health and safety category or to program operations at the State's discretion.

Client Education: Client education, including information on the proper operation of the heating equipment and installed smoke or carbon monoxide detectors, should be provided. Of critical importance is strong client education regarding the dangers of carbon monoxide and excessive moisture levels, particularly if any unvented space heaters are left in the dwelling as a secondary heat source, or emergency back-up.

Other Heath and Safety Consideration: Electrical wiring and chimneys should be checked to ensure they are in good condition and that no obvious building code violations are evident. Masonry chimneys used by vented space heaters should be properly lined in compliance with the IFGC. Safety inspection related to the space heater should include, but not be limited to, a check for adequate floor protection and code-compliant clearances to walls and other combustible materials. Even though many vented space heaters are manufactured with spill switches, it is still a requirement that a worst-case depressurization draft test be performed on all vented units.

Compliance with Local Code, Permitting, and Inspection Requirements: Installation of space heaters requires knowledge of appropriate industry standards and adherence to all aspects of the applicable building code(s) in the municipality where installation is taking place. Building permits should be secured, where required, (this is a program operations cost) for all space heater work and final inspection by competent professionals should take place before any heater is put into operation. States are reminded that even licensed heating contractors may not be aware of

the stringent requirements of the Weatherization Program, so their work should be reviewed by Program staff.

IMPLEMENTATION: Grantee health and safety policy, especially as it relates to space heater repair and replacement, in compliance with the above guidance, must be explained in the applicable State plan or appropriate amendment in order to permit Project Management Center review and approval. Funds to address these items as part of weatherization work will be allowable costs. It is especially important to insure that adequate inspection, safety, liability, and insurance procedures exist and are followed. In all cases, an education component for clients should be a part of the space heater work. Further, testing for indoor air quality, especially carbon monoxide levels in homes with unvented space heaters, should be performed. The cost to purchase the testing device and mechanical tools necessary to check for indoor air quality and to train personnel to do the testing are allowable program expenses. These charges may be made to the program operations cost category.

RELATED MATERIALS AND DOCUMENTS:

The following pamphlets and fact sheets may be useful for educating clients and training staff.

CONSUMER PRODUCT SAFETY COMMISSION PAMPHLETS (CPSC, http://www.cpsc.gov/cpscpub/pubs/pub_idx.html):

Smoke Detectors Can Save Your Life (English and Spanish versions)
Carbon Monoxide Detectors Can Save Lives
Carbon Monoxide Questions and Answers (English and Spanish versions)
The Invisible Killer (CO) (English)
The Senseless Killer (CO) (Spanish)
What You Should Know About Space Heaters

Product Safety Fact Sheet - No. 98: Electric Space Heaters
Product Safety Fact Sheet - No. 97: Kerosene Space HeatersProduct Safety Fact Sheet - No. 99: Ground-Fault Circuit Interrupter (GFCI)
Product Safety Fact Sheet - No. 566: Home Fire Safety Checklist (English and Spanish versions)

Ronald Shaw
Acting Program Manager
Office of Weatherization and Intergovernmental Program
Energy Efficiency and Renewable Energy

Attachment 3-2 (10-01-2008)

MISSOURI WEATHERIZATION
FINAL INSPECTION FORM

Job Number: _____ Client Name: _____

Building and Blower Door Test Conditions

Indoor Temperature (F)		Surface Area (ft^2)	
Outdoor Temperature (F)		# of Stories	
Volume (ft^3)		# Occupants	
Floor Area (ft^2)		Wind Shielding	

Blower Door Test Data

Pre-test ☐ Depressure ☐ Pressure			**Post-test** ☐ Depressure ☐ Pressure	
Building Pressure			Building Pressure	
Flow Ring Installed		**Minimum Airflow Standard**	Flow Ring Installed	
Fan Pressure			Fan Pressure	
Flow (cfm)			Flow (cfm)	
Results		**CFM_{50}**	**Results**	
CFM_{50}			CFM_{50}	
ACH_{50}			ACH_{50}	
CFM_{50}/ft^2		Building CFM	CFM_{50}/ft^2	
ALA (sq in)		Occupant CFM	ALA (sq in)	
Tested by (initials)		Adjusted N Factor	**Tested by (initials)**	

FINAL INSPECTION CERTIFICATION: This dwelling has been final inspected by the inspector whose signatue appears below. He/she certifies that the weatherization work performed on this home has been properly done in accordance with the Missouri Weatherization State Plan and Technical Standards.

Within the specified guidelines the agency has:

Correctly followed the NEAT requirements/Mobile Home Weatherization - Priority System	☐ Yes	☐ No
Combustion appliances are properly vented and draft is within standards	☐ Yes	☐ No
Carbon Monoxide levels are within the standards for equipment and indoor air quality	☐ Yes	☐ No
Installed on the home all materials listed on the job work order	☐ Yes	☐ No
Correctly followed the cost limits	☐ Yes	☐ No
Provided quality workmanship that meets or exceeds the Missouri Weatherization Standards	☐ Yes	☐ No

Final Inspector (Print Name) _____ Signature _____ Date _____ ☐ Home Passed ☐ Home Failed

Location of Weatherization Labels

Site-Built Home

1. ☐ Basement Floor Joist
   Location: _____
   ☐ Attic Rafter
   Location: _____
2. ☐ Electric Panel
   ☐ Water Heater
   ☐ Heating System

Mobile Home

1. ☐ Heating System Compartment
   ☐ Water Heater Compartment
2. ☐ Electric Panel
   ☐ Water Heater
   ☐ Heating System

Comments or Rework Required: _____

Inspection of Rework Required: ☐ Passed ☐ Failed

Final Inspector (Print Name) _____ Signature _____ Date _____

July 2004

Attachment 3-3.1 (10-01-2008)

Missouri Weatherization Assistance Program

Client Interview & Auditor Assessment Form

Name:	Job #	Date:
Address:	City/Zip:	Phone:

General Information

How long have you lived here?	Years		Approximate age of home?		Years
Does your home or certain rooms get too warm? ☐ Yes ☐ No			If yes where:		
Does your home or certain rooms get too cold? ☐ Yes ☐ No			If yes where:		
Do you have any noticable drafty areas? ☐ Yes ☐ No			If yes where:		
Do you close off any rooms during heat season? ☐ Yes ☐ No			If yes where:		
Any noticealbe moisture problems? ☐ Yes ☐ No			If yes where:		
Exhaust fans? ☐ Yes ☐ No	If Yes what type?	☐ Bath exhaust	☐ Kitchen exhaust	☐ Whole-house fan	
Do you have a cloths dryer? ☐ Yes ☐ No		☐ Electric ☐ Gas	Is dryer vented to outside? ☐ Yes ☐ No		
Do you have a fireplace? ☐ Yes ☐ No	If Yes, working damper? ☐ Yes ☐ No		Use fireplace often? ☐ Yes ☐ No		

Heating, Air Conditioning & Domestic Hot Water

Did the primary heating system work last winter? ☐ Yes ☐ No		Any repairs on heating system in last 2-3 years? ☐ Yes ☐ No	
Heating system clean & tune in past 2-3 years? ☐ Yes ☐ No		Do you change your filter regularly? ☐ Yes ☐ No	
Do you use separate space heaters for heating? ☐ Yes ☐ No		If yes fuel type: ☐ Electric ☐ Gas ☐ Kerosene ☐ Other	
Do you use your cook stove for heating? ☐ Yes ☐ No		Cook stove fuel type: ☐ Electric ☐ Gas	
Do you have a setback thermostat? ☐ Yes ☐ No		If yes high setting is: F^o	Low setting: F^o
If no programmable thermostat, do you practice manual setback at certain times? ☐ Yes ☐ No			

Health & Safety Issues

Any dizziness, headaches, nausea flu-like symptoms during heating season? ☐ Yes ☐ No		
Is there any condensation build-up in your home? ☐ Yes ☐ No	If Yes where:	
Is there mold or mildew in your home? ☐ Yes ☐ No	If Yes where:	
Does you basement get wet during certain times of the year? ☐ Yes ☐ No	If Yes when/where:	
Has your home been certified as free from lead-based paint? ☐ Yes ☐ No		
Has any member of your household been tested for lead exposure? ☐ Yes ☐ No		
If tested for lead, what were the results?		

Do you have any concerns I have not addressed?

Auditor Pollution & Moisture Assessment (Check all that apply)

Moisture		Mold/Mildew	Other Hazards
☐ Dirt Floor	☐ Kitchen Vent	☐ Crawlspace	☐ Lead Paint
☐ Standing Water	☐ Bathroom Vent	☐ Basement	☐ Asbestos
☐ Sump Pump	☐ Sill Rot	☐ Bathroom	☐ Radon
☐ Water Staining	☐ Roof Leaks	☐ Kitchen	☐ Unsafe Wiring
☐ Firewood	☐ Gutters	☐ Attic	☐ Carbon Monoxide
☐ Clothes Drying	☐ Plumbing Leaks	☐ Windows	☐ Unvented Combustion
☐ Dryer Not Vented	☐ Aquarium	☐ Ceiling	
☐ Unvented Heater		☐ Walls	

Attachment 3-3.2 (10-01-2008)

Missouri Weatherization Assistance Program

Worst Case Draft Test Form

Name:	Job #	Date:

COMBUSTION APPLIANCE ZONE (CAZ) WORST CASE DRAFT TEST		
Test Steps (refer to Technical Standards for details)	**Pre Test**	**Post Test**
1. Inspect combustion appliances and venting before test setup.		
2. Put dwelling in wintertime condition.		
3. Record outdoor temperature.	°F	°F
4. Deactivate all combustion appliance and exhaust fans.		
5. Close all operable vents.		
6. If furnace, replace or clean filter if needed.		
7. Check or clean lint filter in dryer.		
8. Setup and adjust manometer to measure CAZ with reference to (WRT) outdoors.		
9. Setup pressure hoses to measure CAZ with reference to WRT outdoors.		
10. With all interior doors open, record Baseline Pressure, CAZ WRT outdoors.	Pa	Pa
11. Turn on all exhaust fans and record Exhaust Pressure, CAZ WRT outdoors.	Pa	Pa
12. If furnace, activate air handler. Record Air Handler Pressure, CAZ WRT outdoors.	Pa	Pa
13. Position all interior doors for worst-case depressurization in CAZ.		
14. Position CAZ door for worst-case depressurization in CAZ. (circle door position)	Open / Closed	Open / Closed
15. Is worst-case depressurization with air handler on or off? (circle switch position)	On / Off	On / Off
16. Record worst-case depressurization CAZ WRT outdoors.	Pa	Pa
17. What are the dominant forces causing depressurization?		
18. Under worst-case conditions, fire appliance. Does it spill after 1 minutes.		
a. Appliance 1 description:	Yes / No	Yes / No
b. Appliance 2 description:	Yes / No	Yes / No
c. Appliance 3 description:	Yes / No	Yes / No
d. Appliance 4 description:	Yes / No	Yes / No
19. Under worst-case conditions, fire appliance and measure draft.		
a. Appliance 1	Pa	Pa
b. Appliance 2	Pa	Pa
c. Appliance 3	Pa	Pa
d. Appliance 4	Pa	Pa
20. If appliance fails correct problem.		
21. If dwelling has other combustion appliance zones, repeat test there.		
22. Return dwelling, exhaust fans, and combustion appliances to normal settings.		

Notes:

--- For Use with Worst-Case Draft Test ---

Acceptable Draft Test Ranges	
Outside Temperature (degree F)	**Draft Pressure Standard (Pa)**
<10	-2.5
10-90	(T_out / 40) - 2.75
>90	-0.5

Acceptable Appliance Spillage Periods	
Appliance Type	**Spillage Test Period (minutes)**
Water Heater, Gravity Furnace, Boiler	1.0
Space Heater	1.0
Forced Air Furnace	1.0

CAZ Depressurization Limits	
Venting Condition	**Limit (Pascals)**
Orphan natural draft water heater (including outside chimneys)	-2
Natural draft boiler or furnace commonly vented with water heater	-3
Natural draft boiler or furnace with vent damper commonly vented with water heater	-5
Individual natural draft boiler or furnace	-5
Induced draft boiler or furnace commonly vented with water heater	-5
Power vented or induced draft boiler or furnace alone	-15
Exhaust to chimney-top draft inducer; high static pressure flame retention head oil burner; direct vented appliances; sealed combustion appliances	-50

--- For Use with Building Air Standard Test Procedure ---

Typical Exhaust Appliance Nominal CFM	
Appliance	***CFM Nominal***
Bathroom exhaust fan	50
Kitchen range hood	100
Kitchen wall fan	250
Kitchen down-vent fan (Jenn-Air)	300 - 600
Dryer	180
Central Vacuum	150
Fireplace	200 - 400

Attachment 3-3.3 (10-01-2008)

Missouri Weatherization Assistance Program

Diagnostic Field Form

Name:		Job #:		Date:

BLOWER DOOR TEST DATA & BLOWER DOOR GUIDED AIR SEALING

Test Conditons:		Baseline Pressure:	Pa	Flow Ring Used: ◉ Open ○ 1 ○ 2 ○ 3

Test	***CFM 50***		**CEG/100 CFM50 =**	$75.00	
Initial Test		*No. in Crew*	*Minutes*	*CFM 50 Reduction*	*Cost / 100 CFM 50*
Test 1					
Test 2					
Test 3					
Test 4					
Test 5					
Final Test		**Minimum Airflow Requirement =**		CFM_{50}	

ZONE PRESSURE TESTING (ZPT)

Zone:		Test 1	Test 2	Zone:		Test 1	Test 2
House/Zone, P_1		Pa	Pa	House/Zone, P_1		Pa	Pa
Zone/Outside, P_1		Pa	Pa	Zone/Outside, P_1		Pa	Pa
Hole Added		☐ H/Z ☐ Z/O	☐ H/Z ☐ Z/O	Hole Added		☐ H/Z ☐ Z/O	☐ H/Z ☐ Z/O
Hole in^2 or Door-Open CFM_{50}		In^2	In^2	Hole in^2 or Door-Open CFM_{50}		In^2	In^2
House/Zone, P_2		Pa	Pa	House/Zone, P_2		Pa	Pa
Zone Outside, P_2		Pa	Pa	Zone Outside, P_2		Pa	Pa
CFM_{50} House/Zone				CFM_{50} House/Zone			
CFM_{50} Zone/Outside				CFM_{50} Zone/Outside			
CFM_{50} Total Path				CFM_{50} Total Path			

DUCTWORK LEAKAGE/AIR HANDLER ASSESSMENT

Room-to-Room Pressure Testing

#	Room	Test	#	Room	Test
1		Pa	6		Pa
2		Pa	7		Pa
3		Pa	8		Pa
4		Pa	9		Pa
5		Pa	10		Pa

If a room is more than 3 Pascals different from main body of house or if a fireplace or a wood stove d raw any portion of its combustion from a zone that is depressurized more than -3 Pascals WRT outside then relieve pressure.

Duct Leakage to Outdoors

	Test 1	Test 2
Tests Pressure	Pa	Pa
Flow Ring Used: (check one)	☐ Open ☐ 1 ☐ 2 ☐ 3	
Fan Pressure	Pa	Pa
Fan Flow (leakage to outdoors)	CFM_{50}	CFM_{50}
Inches^2 leakage to outdoors	in^2	in^2
CFM leakage as percentage of conditioned floor area	%	%

PRESSURE PAN TESTING AND LEAKAGE ASSESSMENT

#	Duct	Test 1	Test 2	#	Duct	Test 1	Test 2
1		Pa	Pa	11		Pa	Pa
2		Pa	Pa	12		Pa	Pa
3		Pa	Pa	13		Pa	Pa
4		Pa	Pa	14		Pa	Pa
5		Pa	Pa	15		Pa	Pa
6		Pa	Pa	16		Pa	Pa
7		Pa	Pa	17		Pa	Pa
8		Pa	Pa	18		Pa	Pa
9		Pa	Pa	19		Pa	Pa
10		Pa	Pa	20		Pa	Pa

Can't reach fifty factors

House/ Zone Pressure	Pressure Pan Multiplier
50	1.00
45	1.10
40	1.25
35	1.42
30	1.66
25	2.00
20	2.50
15	3.50
10	5.00
5	10.0

Attachment 3-3.4 (10-01-2008)

Missouri Weatherization Assistance Program

Mechanical Systems Audit Form

Name:		Job #		Date:	
GENERAL SYSTEM INFORMATION					
Manufacturer:			Serial No:		
Model No.:			Input: kBtu	Output:	kBtu
Primary Fuel Type:	☐ Natural Gas ☐ Propane ☐ Oil ☐ Electric ☐ Wood ☐ Other				
Secondary Fuel Type:	☐ Natural Gas ☐ Propane ☐ Oil ☐ Electric ☐ Wood ☐ Other				
Gas Leaks	☐ Yes ☐ No		Open Air Returns:	☐ Yes ☐ No	
Venting Problems:	☐ Yes ☐ No		Asbestos Present:	☐ Yes ☐ No	
Carbon Indicators:	☐ Yes ☐ No		Safety Disconnects Present:	☐ Yes ☐ No	
Ductwork Holes:	☐ Yes ☐ No		Heat Exchanger Safe:	☐ Yes ☐ No	
CONTROLS & COMPONENTS					
Thermostat Location:	☐ OK ☐ Relocate		Blower Drive	☐ Belt ☐ Direct Drive	
Anticipator:	☐ OK ☐ Needs Adjustment		Blower Wheel	☐ Clean ☐ Dirty	
High Limit Setting	☐ OK ☐ Needs Adjustment		Air Conditioning Coil	☐ Yes ☐ No	
Fan On/Off Control	☐ OK ☐ Needs Adjustment		A-Coil Condition	☐ Clean ☐ Dirty	
Comments Relevant to Workscope Development					

-over-

DIAGNOSTIC TESTS					
Return Air Temp (F^o)		Supply Plenum (F^o)		Heat Rise (F^o)	

Furnace

Port 1	Port 2	Port 3	Port 4

Water Heater	Gas Oven	Other 1	Other 2

Calculating Estimated Energy Savings

Site Built Homes - NEAT

Job Number: _____

Annual Energy & Cost Savings

	kWh	MMBtu
Space Heating		
· Electric - MMBtu x 293 = kWh/MMBtu	_____	_____
· Non-electric - MMBtu saved	_____	_____
Space Cooling - kWh saved	_____	_____
Lighting & Refrigerators - kWh saved	_____	_____
Water-Heating		
· Electric - kWh saved	_____	_____
· Non-electric - kWh x 0.003413 MMBtu/kWh	_____	_____
Totals	_____	_____
Correction Factor - multiply each category by 0.65	x 0.65	x 0.65
Total House		

Attachment 3-4.2 (10-01-2008)

Missouri Energy Saving Estimates

SITE-BUILT HOUSES

Savings estimated by NEAT and printed out in the Annual Energy and Cost Savings table on the NEAT Recommended Measures form will be used to estimate savings for site-built houses.

Space-Heating

If the primary space-heating system is electric, add up the savings under the Heating column and multiply by 293 to convert MMBtu to kWh:

_____ MMBtu x 293 kWh/MMBtu = _____ kWh saved.

OR

If the primary space-heating system is non-electric (e.g., natural gas, propane), add up the savings under the Heating column: _____ MMBtu saved.

Space-Cooling

Add up the savings under the Cooling column: _____ kWh saved.

Lighting and Refrigerators

Add up the savings for all lighting and refrigerator measures under the Baseload column:

_____ kWh saved.

Water-Heating

If the hot water system is electric, add up the savings for all water-heating measures under the Baseload column: _____ kWh saved.

OR

If the hot water system is non-electric (e.g., natural gas, propane), add up the savings for all water-heating measures under the Baseload column and multiply by 0.003413 to convert kWh to MMBtu:

_____ kWh x 0.003413 MMBtu/kWh = _____ MMBtu saved.

Total House

Add up the MMBtu and kWh savings estimated for space-heating, space-cooling, lighting and refrigerators, and water-heating, and multiply by 0.65 to account for NEAT's over prediction tendencies to estimate the total savings for the house:

_____ MMBtu x 0.65 = _____ total MMBtu saved

_____ kWh x 0.65 = _____ total kWh saved

Attachment A (10-01-2008)

Site Built Home

Missouri DNR/EC Weatherization Housing Quality Inspection Form

Attachment A

Client Name: _____ Agency: _____ Blower Door Pre Test: _____

Address: _____ Job No: _____ Bower Door Post Test: _____

City/Zip _____ Difference: _____

	SAT	N/A	DEF	Notes:
Infiltration	☐	☐	☐	
Air Leakage Areas	☐	☐	☐	
Door Treatments	☐	☐	☐	
Window Treatments	☐	☐	☐	
Wall Insulation	☐	☐	☐	
Kneewalls	☐	☐	☐	
Accesses	☐	☐	☐	
Attic Insulation	☐	☐	☐	
Damming & Shielding	☐	☐	☐	
Venting	☐	☐	☐	
Accesses	☐	☐	☐	
Foundation/Floor Insulation	☐	☐	☐	
Sillbox	☐	☐	☐	
Venting	☐	☐	☐	
Accesses	☐	☐	☐	
Vapor Retarder	☐	☐	☐	
Mechanical Systems	☐	☐	☐	
Clean & Tune	☐	☐	☐	
Heating System Repairs	☐	☐	☐	
Ductwork	☐	☐	☐	
Duct Insulation	☐	☐	☐	
Water Heater	☐	☐	☐	
Incidental Repairs	☐	☐	☐	
Door Replacements	☐	☐	☐	
Window Replacements	☐	☐	☐	
Other	☐	☐	☐	
Miscellaneous	☐	☐	☐	
General Heat Waste	☐	☐	☐	
Health & Safety	☐	☐	☐	
Storm Windows	☐	☐	☐	
Weatherization Labels	☐	☐	☐	
NEAT Audit	☐	☐	☐	

Housing Quality ☐ Passes ☐ Passes with Reworks ☐ Fails

Inspected for Quality by: _____

Attachment B (10-01-2008)

Mobile Home

Missouri DNR/EC Weatherization Housing Quality Inspection Form

Attachment B

Client Name: _____ Agency: _____ Blower Door Pre Test: _____

Address: _____ Job No: _____ Bower Door Post Test: _____

City/Zip _____ Difference: _____

	SAT	N/A	DEF	NOTES
General Air Sealing	☐	☐	☐	
Air Leakage Areas	☐	☐	☐	
Door Treatments	☐	☐	☐	
Window Treatments	☐	☐	☐	
Wall Insulation	☐	☐	☐	
Belly Insulation	☐	☐	☐	
Belly Repairs	☐	☐	☐	
Vapor Barrier	☐	☐	☐	
Roofing Insulation	☐	☐	☐	
Interior Storms	☐	☐	☐	
Mechanical Systems	☐	☐	☐	
Clean & Tune	☐	☐	☐	
Heating System Repairs	☐	☐	☐	
Heating Sys. Replacement	☐	☐	☐	
Ductwork	☐	☐	☐	
Water Heater	☐	☐	☐	
Incidental Repairs	☐	☐	☐	
Door Replacement	☐	☐	☐	
Window Replacements	☐	☐	☐	
Other	☐	☐	☐	
Miscellaneous	☐	☐	☐	
General Heat Waste	☐	☐	☐	
Health & Safety	☐	☐	☐	
Weatherization Labels	☐	☐	☐	

Housing Quality ☐ Passes ☐ Passes with Reworks ☐ Fails

Inspected for Quality by: _____